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ENVIRONMENTAL GEOLOGY OF THE GREATER HARRISBURG METROPOLITAN AREA

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Environmental Geology Report 4

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ENVELOPE COVER--Oblique aerial view of the greater Harrisburg area looking south down the Susquehanna River. Photograph courtesy of the Pennsylvania Department of Transportation.

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PREFACE

The text and factor maps presented here provide the user with information on the topography, soils, geology, mineral and water resources of the Harrisburg metro area. In planning for any land use project in this area, these maps should enable the user to identify areas which conform with his requirements and guidelines. A composite view of the various factors can be obtained by combining the maps that represent the various environmental factors into a composite map that will serve to distinguish the favorable areas from the unfavorable ones; the potentially favorable areas will then appear as "windows" and will enable the focus of attention to be placed on these specific sites.

The most important information which the maps provide the reader is identification of important natural land conditions and delineation of the limitations that nature has imposed upon the land.

These data will provide major assistance for preliminary planning of proposed projects in the area. Depending upon the nature of the proposed project, additional detailed on-site investigation may be needed.

Arthur A. Socolow
State Geologist

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CONTENTS

Page

Preface iii
The role of geology in urban studies and planning 1
    Selected references 2
Description of the Harrisburg metro area and historical review 3
    Selected references 5
Environmental framework 7
    Introduction 7
    The terrain 7
        Relief 7
        Slope 12
        Drainage 12
        Soils 14
        Selected references 15
    Geology 16
        The geologic map 16
        Rock descriptions 16
            Unconsolidated surficial deposits 16
            Martinsburg Formation 17
            Limestone and dolomite formations 18
            Diabase and "baked zone" 19
            Triassic red beds 19
        Selected references 20
    Water resources 21
        General 21
        Future water supply alternatives 26
        Selected references 26
    Mineral resources 27
        General 27
        Minerals future 29
            Readily available 29
            Agricultural, residential-industrial or mineral extraction land use—a confrontation ahead 30
            Abandoned quarry site uses 31
        Selected references 34

Page

Engineering characteristics of the rocks 35
General 35
Special engineering geology concerns in the metro area 36
Waste disposal systems 36
Solid waste disposal sites 36
On-lot septic systems 37
Deep-well liquid waste disposal 38
Sinkholes 38
Selected references 39
Summary 41
Acknowledgements 42

ILLUSTRATIONS

FIGURES

Figure 1. Index map of project area 4
2. Projected growth patterns for metro area 5
3. Population projections for metro area 6
4. Water-bearing properties of rocks in metro area . 22
5. Hydrographs of three water wells 24

PLATES

(in envelope)

Plate 1. Layered relief map
2. Slope map
3. Drainage and flood-prone area map
4. Soil associations map
5. Geologic and mineral resource map
6. Ground water availability map
7. Engineering geology map

ENVIRONMENTAL GEOLOGY OF THE GREATER HARRISBURG METROPOLITAN AREA

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THE ROLE OF GEOLOGY IN URBAN STUDIES AND PLANNING

To help provide orderly, intelligent and efficient growth for an area, it is essential that the geologic conditions, existing mineral resources, and water resources be delineated, and that this information be integrated with all the planning tools and procedures. The purpose of this atlas is to provide practical compilation of all the available geologically-related data as an aid to planning in the Harrisburg metropolitan area. It is important that government decision-makers and the public of this area be aware of the constraints that geologic conditions may impose upon the construction of engineering works, disposal of waste materials, availability of water supplies and ultimately, perhaps, the distribution of population centers. The application of geologic concepts to man's related problems is aptly called *Environmental Geology*.

The rapid growth of population and of industrial-transportation facilities places a formidable strain on the available land, water, and mineral resources of a region. Obviously, there are limitations to the quantity and quality of these three essential elements of man's very existence. In the past, vital land, water and mineral resources have been consumed, modified, and often wasted as though they were self-cleansing and perpetually renewable. The real impact of consuming, modifying, and wasting resources has not become apparent until this generation. Until now, there has always been enough dilution of pollution and more pressing social and economic catastrophes to divert man's attention away from the long-range and lasting results of the mismanagement of resources.

Many observers argue that environmentalists, including geologists, are "crisis-oriented"; that we merely run from problem to problem, patching it up or otherwise "fixing" it. Geologists hope to go beyond the solution of short-term crisis by applying environmental geology to the demographic, industrial and recreational projections so that sound plans for the future can be developed and set in motion. These plans will enable us to prepare for future needs, shortages, problems and life style as they relate to the natural environment: that is the essence of environmental geology.

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DESCRIPTION AND HISTORICAL REVIEW OF THE HARRISBURG METRO AREA

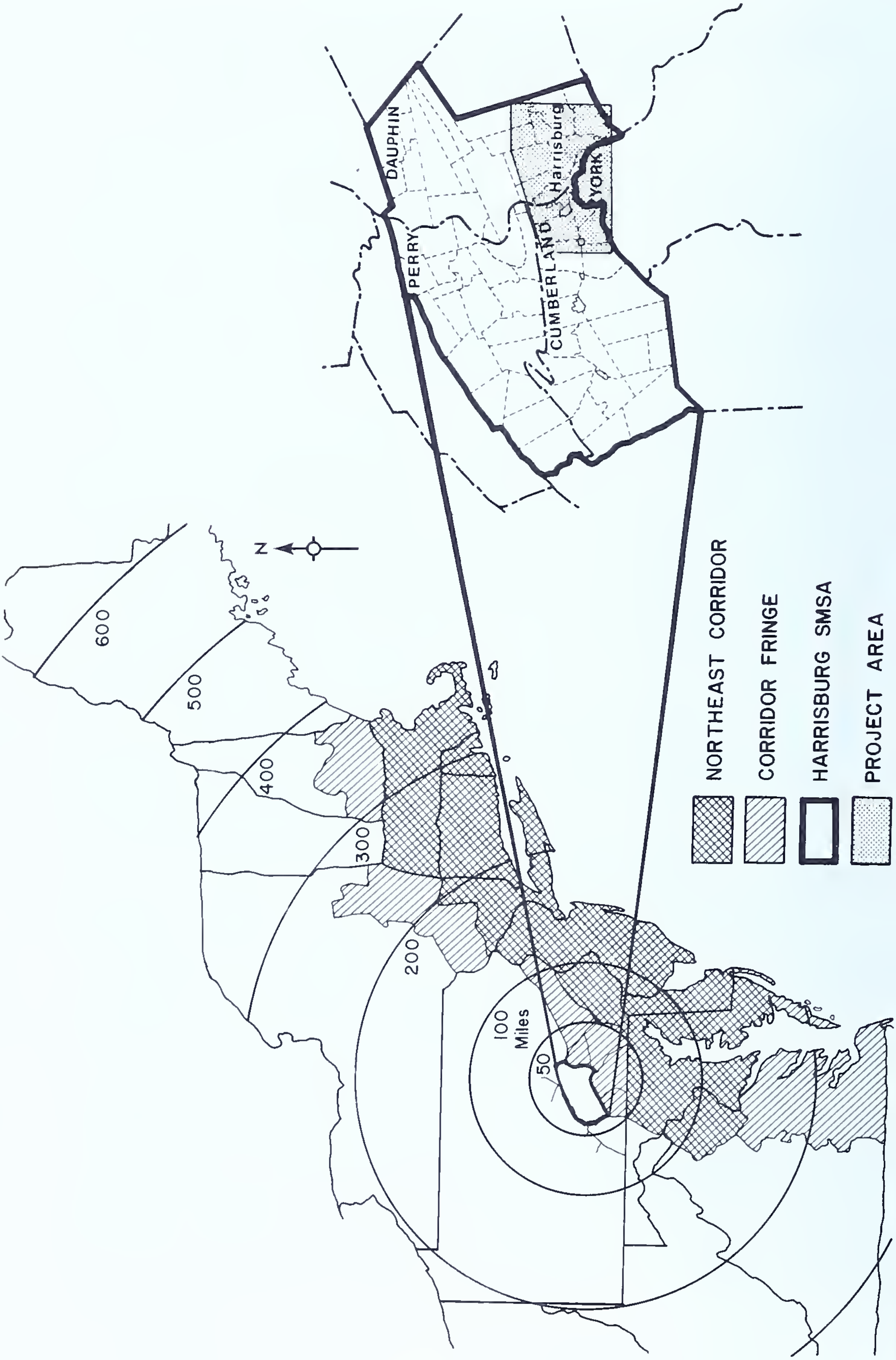
The area considered in this report is shown in Figure 1 and covers part of the Standard Metropolitan Statistical Area (SMSA) as used by the United States Bureau of the Census; the official Harrisburg SMSA includes Cumberland, Dauphin and Perry Counties. The study area covers over 300 square miles in Cumberland, Dauphin and York Counties. It was selected by considering urban growth patterns, historical relationships of settlements, limits of map size, and availability of geological data. Harrisburg, the capitol of the commonwealth, is located in the center of the Harrisburg metropolitan (metro) area study.

The flat valleys of limestone and dolomite aligned in a general east-west direction, and the north-south Susquehanna River valley are the two main natural transportation corridors in the Harrisburg area. The site of the city of Harrisburg is at the intersection of these two transportation routes. The Harrisburg area with its advantageous geographic position has become a highly sophisticated transportation and distribution center.

Government and services are an important part of the Harrisburg metro economy. The state government of Pennsylvania is a major employer, as are two major federal military installations.

Figure 2 shows the presently developed areas of the Dauphin-Cumberland portion of the area, the modified trends of existing areas, and the development of regional cities. Modified trends are assumed expansions of existing settlement areas, which are guided in a reasonable fashion by governmental planning.

Figure 3, taken from local planning commission reports, shows that population growth is expected to be steady and appreciable to 1990. Until now, the largest portion of population growth has been concentrated in the Great Valley from Mechanicsburg to Hershey, with the major portion in Cumberland County. Planners expect that the population will continue to show the greatest rate of growth in Cumberland County, although Dauphin County will also grow rapidly. The valley will continue to be the area of major increase in both Cumberland and Dauphin Counties. The distribution of urban expansion will be wider in Dauphin County; i.e., it will move eastward from the areas of maximum population density and occupy the space from the Pennsylvania Turnpike to the foot of Blue Mountain while the Cumberland County growth will be an


DAUPHIN
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CUMBERLAND
Harrisburg
YORK
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600
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NORTHEAST CORRIDOR
CORRIDOR FRINGE
HARRISBURG SMSA
PROJECT AREA

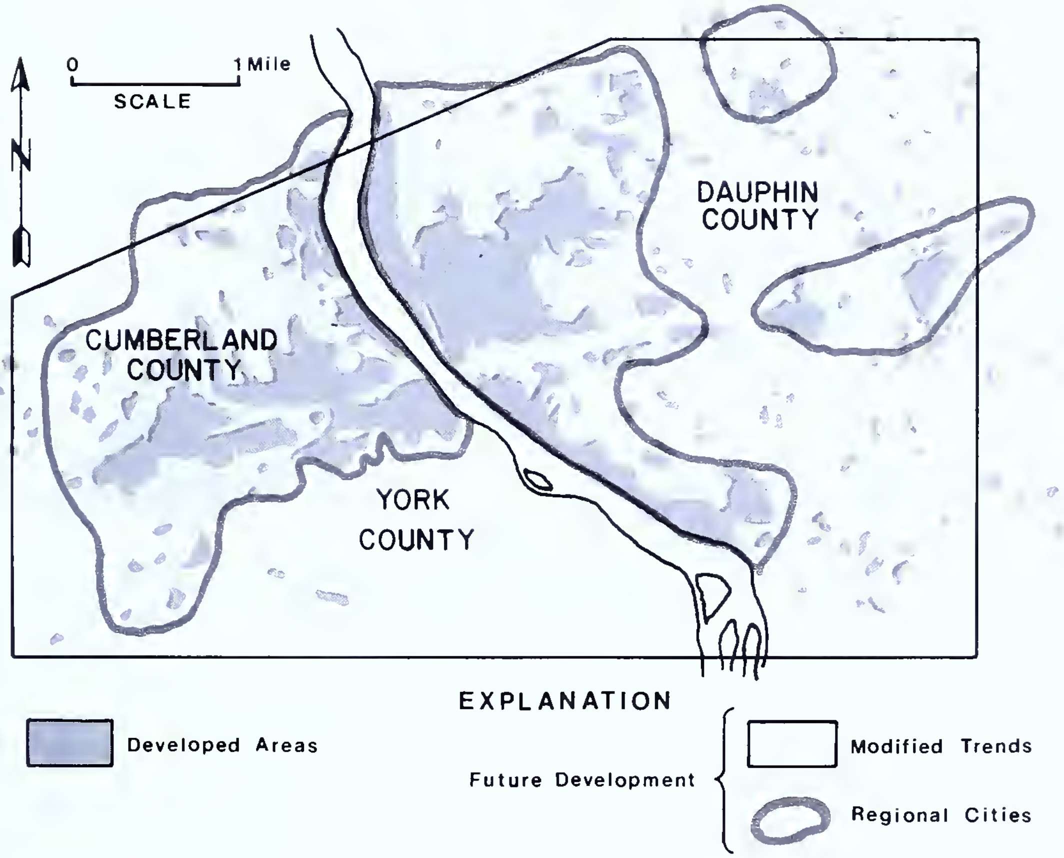

Figure 2. Projected growth patterns for metro area (Modified from Tri-County Planning Commission)

enlargement of the presently concentrated areas. In the York County area, population is expected to expand into southern Fairview Township, adjacent to Interstate 83.

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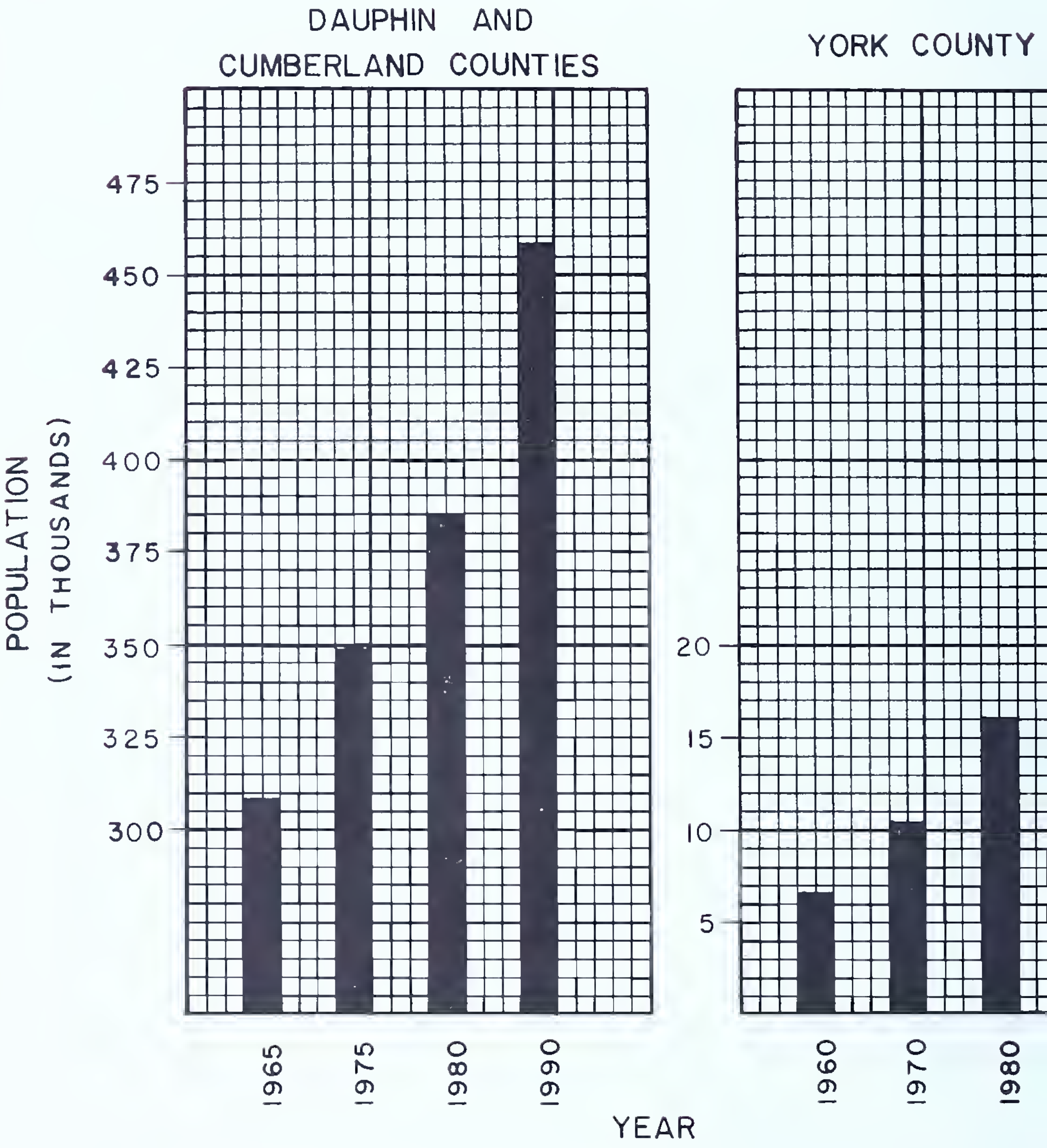

Figure 3. Population projections for metro area

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ENVIRONMENTAL FRAMEWORK

INTRODUCTION

At the beginning of this study, all published and unpublished geologic and hydrologic reports available for the area were examined. Reports of the Tri-County Regional Planning Commission and the York County Planning Commission were reviewed. Data on water wells, water quality and engineering characteristics of the rocks were obtained from local contractors, well drillers, governmental agencies and private citizens. The maps, descriptions, tabulations and conclusions of this report are based on those assembled data.

The five major components of an environmental framework are significant to the planning process: terrain, geology, water resources, mineral resources and engineering geology. The chief indicators of these major components are maps and tables, charts and illustrations. Environmental problems usually are complex and involve several interrelated factors; thus, rarely can information from one map be used alone and provide an adequate answer to a specific environmental geology problem. Usually a combination of maps will better provide an answer. Hence, the concept of an environmental geology atlas.

THE TERRAIN

Relief

The topography or shape of the land surface is closely related to the type of bedrock. Hard rocks, such as quartzite, sandstone, or conglomerate, are resistant to erosion and form the mountains. Less resistant linestone and shale formations underlie the flat and rolling areas respectively. Plate 1, the Layered Relief Map, is suited to a rapid analysis of this topographic relief. The placement of utilities, the location of various industries, the siting of scenic vistas, and the protection of high vantage points, are only a few practical applications of this map.

The Harrisburg metro area can be separated into three generalized topographic categories:

1. A belt of highest elevations, greatest relief, roughest terrain and underlain by resistant quartzites, sandstones, and conglomerates is located in the extreme northern part of the

Diabase ridge, Fairview Township, York County.

report area. Elevations of Blue Mountain are over 1000 feet. South of the Pennsylvania Turnpike and the borough of Hummelstown, prominent, high rounded hills are held up by tough diabase, "baked" sediments, tough sandstones and some conglomerates. Round Top, a local landmark in Derry Township, Dauphin County, is a hill held up by diabase that attains an elevation of 925 feet (see Plate 1).

2. A terrain with medial elevations, transitional between high and low elevation areas, and underlain predominately by shale

Rolling topography underlain by shale; Blue Mountain in background, East Hanover Township, Dauphin County.

comprises the largest portion of the metro area. The land is rolling and occasionally deeply dissected. Elevations range between 550 feet and 300 feet with an average elevation in excess of 425 feet.

3. The lowest average elevations occur along the flat, east-west trending limestone valley. The valley is essentially flat or very gently undulating, although it may range between 350 and 500 feet in elevation. However, most of the area is below 400 feet.

Flat, east-west trending limestone valley in the vicinity of Hershey.

Topography influences the development of soil and vegetation and has greatly influenced the pattern of urban and agricultural development. A major transportation corridor and many centers of population now occupy the limestone valley between Mechanicsburg and Hershey. The low, flat topography and thick, rich soils were primary factors in the development of this historic valley.

Unique topographic areas and geologic features within the Harrisburg metro area are the focus of growing attention. The interest is in designating these unique natural features for scientific, educational, and aesthetic purposes. Included in the following list are those sites which contain unusual and exceptional aesthetic qualities such as gorges, waterfalls, cliffs and scenic views, as well as individual unique geologic sites and features.

1. Susquehanna Water Gap, at Rockville; intersection of Dauphin, Cumberland and Perry Counties.

2. Indian Echo Cave, Derry Township, Dauphin County.

3. Abandoned brownstone quarries, Derry Township, Dauphin County.

4. Overview, along Railroad Avenue on south slope of Blue Mountain, East Pennsboro Township, Cumberland County.

Slope

In the development and planning of any area, the slope of the land is a major factor. Plate 2 is an experimental, computer-produced slope map compiled for this area by the U. S. Geological Survey.

In discussing the slope of the land, it is important to keep in mind that these natural gradients were created by erosional forces trying to establish a stable condition. Sometimes when man alters these slopes, he upsets this balance and landslides, rock falls, mudslides and soil creep may result as nature tries to restore equilibrium.

In the Harrisburg metro area, soil creep is prevalent and may at times be severe in the southern section where the red sandstones and shales occur. Adequate drainage leading water away from the face of a steep slope and keeping it from entering the top of the slope is advisable where it is desirable to curtail the soil creep.

Drainage

The area is drained directly by the Susquehanna River and its tributaries, Paxton Creek, Spring Creek and Swatara Creek on the east and the Conodoguinet Creek, Yellow Breeches Creek and Fishing Creek on the west. See Plate 3 for the complex network of stream channels, flow direction and watershed boundaries. A comparison of Plate 3 and Plate 5 will show that the limestone areas have virtually no surface drainage and subsurface drainage is dominant. This phenomenon is discussed in the Engineering Geology section.

Swatara Creek in Derry Township, Dauphin County.

Surface drainage is affected by annual precipitation and by physical features such as runoff characteristics and stream channel shape. When a rural area is urbanized, it creates special effects on the hydrologic system: the amount of runoff is increased, impervious surfaces prevent precipitation from entering the ground water, and local streams are forced to carry more water than they formerly did. Flood peaks on these local streams become increasingly higher. Flood frequency is increased because the normal flow will be exceeded more often. Low-flow stream problems are aggravated because there is less ground water available to recharge the stream.

The hydrologic system is complex. In the past, severe floods have occurred in the Harrisburg metro area. The flood of June 24, 1972, was the highest known for the Susquehanna River. The maximum gage height in Harrisburg at Nagle Street on the Susquehanna River during this flood was 32.6 and the corresponding elevation above mean sea level was 322.6 feet. In comparison, the U. S. Weather Bureau's established flood stage at this gaging station is 307 feet above mean sea level.

The Susquehanna River is the principal source of major flooding at Harrisburg but the large tributaries flowing through the area, Conodoguinet Creek, Paxton Creek, Yellow Breeches Creek, and Swatara Creek, frequently overflow their banks.

Homes along Swatara Creek in the village of Union Deposit - a site of frequent flooding.

Every year there is an increase in the damage done by floods; the main reason is the larger number of structures built in flood-prone areas (see Plate 3). A municipality's best defense against a flood tragedy is to regulate the use of the flood plain. Proper land-use zoning can insure that these flood plains are used for agriculture, parks, playgrounds, other outdoor recreational purposes, or as sand and gravel resources. The use of flood plains for residential sites is probably the most hazardous from the standpoint of potential damage.

Soils

An environmental atlas would not be complete without a map and description of the soils present. The Soil Conservation Service of the United States Department of Agriculture, in conjunction with the Pennsylvania State University and the Soil Conservation Commission in the Pennsylvania Department of Environmental Resources, maintains a continuing program of soil studies throughout the commonwealth. Detailed soil information such as crop suitability, seasonal high water table, depth of soil, engineering classification, suitability for sewage lagoons, on-lot septic systems, sanitary landfill sites, and many other soil-related parameters are available for all of the specific soils of the metro area. For specific data see: Zarichansky, Lipscomb, and Kunkle (1969), Kunkle and Lipscomb (1968), and Hersh (1963). The State Soil and Water Conservation Commission, Department of Environmental Resources, Harrisburg, and the Soil Conservation Service, U. S. Department of Agriculture, Harrisburg, maintain files of useful unpublished material.

In general, when soil is mentioned in this report, it is in reference to the material found above the top of the weathered bedrock. This includes the humus zone, the leached zone and the subsoil zone of the typical soil profile. In the legend to Plate 4, the soil type, depth, and the parent bedrock are given. These soil data along with depth to water information are especially valuable in determining suitable landfill sites, lagoon sites, and in developing solid waste management plans.

The depth to unweathered bedrock, or mantle thickness (see Plate 6), is an important factor in planning land use. Areas with a depth to bedrock of less than 10 feet permit easy access to the bedrock for any type of mineral extraction. These areas are also favorable for heavy construction that depends on solid bedrock for foundation support. A thin mantle cover may restrict the location of sanitary landfills, underground utility lines, septic tanks, and highway corridors. Areas with a depth to bedrock of 10 to 50 feet have few restrictions where thick soil is needed.

The infiltration rate of soils, or soil permeability, is an important consideration in determining land use, be it urban settlement, industry, agriculture, or open space. Rapid infiltration permits rapid recharge of the groundwater system and these areas are suited to most types of construction where well-drained soils are desired. Where a high percentage of clay is present in the soil, the permeability is low, the infiltration rate is slow and the soils may be suited for sanitary landfills and farm ponds.

Detailed soils maps are needed for specific on-site evaluations; reference is made to such maps and their use is encouraged.

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GEOLOGY

The Geologic Map

The Geologic Map (Plate 5) shows the distribution of rock formations in the metro area. Structural features of the rocks such as the inclination of the beds, orientation of faults, fractures and folds in the rock are noted by symbols. Information on geologic structure (Plates 5 and 7) is useful for locating optimum water well sites, mineral deposits, and evaluating foundation sites.

Each rock formation is referred to by a specific name and shown on the map by a particular color and code-letter designation. The reader will discover after examining the description of these geologic formations listed on the table accompanying Plate 5 that some of the units are similar but never identical.

The structural symbols on the map help to show the position and structural elements of the rock formations at a particular location. One may find rock beds dipping in various compass directions, but a close examination will show that certain directions of dip tend to predominate.

The structural cross sections (see Plate 5) show views of slices through the earth's crust in the metro area along two, general north-south lines. The various portions of the rocks and the relationship of rock type to variations in elevation are depicted in these illustrations.

Rock Descriptions

The general character, thickness and relative age of the rock units are given on the table accompanying Plate 5. In addition, other characteristics of these rock units are listed below:

Unconsolidated surficial deposits

Recent alluvial deposits (of stream origin) consist mainly of fine silt and sand concentrated along flood-plain areas adjacent to major streams. Alluvial deposits of coarse gravel derived from glacial melt waters tens of thousands of years ago are restricted to terraces at higher elevations. These are best developed in the Highspire-Middletown, Falmouth, and Harrisburg areas. Recent stream deposits and glacial melt-water debris are not differentiated in Plate 5.

Martinsburg Formation

The Martinsburg Formation, which occurs in a belt north of the limestone valley, has been divided on the map into several recognizable units. Generally, exposures are not large or plentiful. The topography of the area usually is an indication of the particular lithology involved. Cleavage (closely spaced fracturing) is also apparent and often is more pronounced than the bedding. A thin belt of undifferentiated Martinsburg Formation located between the two limestone belts between Hershey and Mechanicsburg is highly deformed by thrust faulting and the rock has undergone slight recrystallization. Outcrops in this area have a very distinctive orange-brown color and can be observed along U. S. Route 322 in Dauphin County.

Highly folded and faulted Martinsburg Formation rocks, Eisenhower Blvd., Swatara Township, Dauphin County.

Martinsburg shale along Route 39, east of Linglestown, Dauphin County

Limestone and dolomite formations

Fourteen limestone and dolomite rock units are mapped in the Harrisburg metro area. Each is different, but general characteristics, such as resistance to erosion, weathering, topographic character and collapse features are similar.

One major characteristic among these rocks is their chemical composition which is reflected in their use and economic value. These limestone and dolomite areas are among the best agricultural lands in the state and they are the principal source of construction material for the region. Land-use policy should be developed to protect these resources where feasible.

Typical limestone outcrop, Derry Township, Dauphin County.

Diabase and "baked zone"

The rock, diabase, is the only igneous rock exposed in the area. Diabase is usually a tough, hard rock, but it can weather severely if extensively broken by fracturing and subjected to circulating ground water. Large, surface boulders are associated with outcrop areas. Diabase is usually found in large, tabular and sheet-like bodies which may cut across or parallel existing, bedded sedimentary rocks.

Large, surface boulders of diabase, southern Dauphin County.

Immediately adjacent to the diabase, the pre-existing rock which was invaded by the molten material shows a zone of variable thickness that has been altered chemically and physically by the intruding diabase. Red and pinkish sandstone are bleached to a grayish color and recemented in part by silica. Red shales have been altered ("baked") to a very tough, bluish-black, purplish rock. "Baked" shale may be more resistant to weathering than some diabase.

Triassic red beds

This section of rock has been separated into four mappable subunits which can be easily identified in the metro area. Most of these rocks are exposed south of the Pennsylvania Turnpike in York and Dauphin Counties.

The dominant unit consists of easily erodible, red shales, siltstone and fine-grained sandstones. The other identifiable units are yellow-brown sandstone, quartz conglomerate, and limestone conglomerate.

Siltstones and sandstones of the Triassic Gettysburg Formation adjacent to the Pennsylvania Turnpike, Fairview Township, York County.

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WATER RESOURCES

General

An abundant supply of surface and ground water is one of Pennsylvania's most valuable natural resources. There are many water-bearing units, or aquifers, in the Harrisburg area (see Plate 6).

Water supplies used in the Harrisburg metro area are derived primarily from surface streams, particularly the Susquehanna River. Ground water is used as a supplementary source for heavy industrial needs and public water supply utilities in suburban and rural areas. In a few small public and private water supply utilities, ground water is the only source. For the future, it appears that surface water will continue to be the principal source (U. S. Army Corps of Engineers, 1974). However, ground water should continue to play an important, though secondary, role. Ground water in this metro area is relatively unused and the reserves available for use should be very attractive in the future. The area should be interested in ground water because it is a resource which is less affected by pollution or drought conditions.

Ground water infiltrates into and moves through rocks of different types in different amounts and at different rates. The ability to extract water from water wells in different rocks varies greatly (see Figure 4). It is important to determine the water availability of the different rock types and formations.

Plate 6 is a ground water map. The rocks are grouped into a range of categories (very poor to excellent) of ground water availability. Specific data is included on the chart. The map includes locations of key water wells, monitored observation wells and surface stream gaging stations.

A careful examination of Plate 6 gives the reader a grasp of the ground water situation for any portion of the project area. This understanding is extremely important to planning as it relates to the

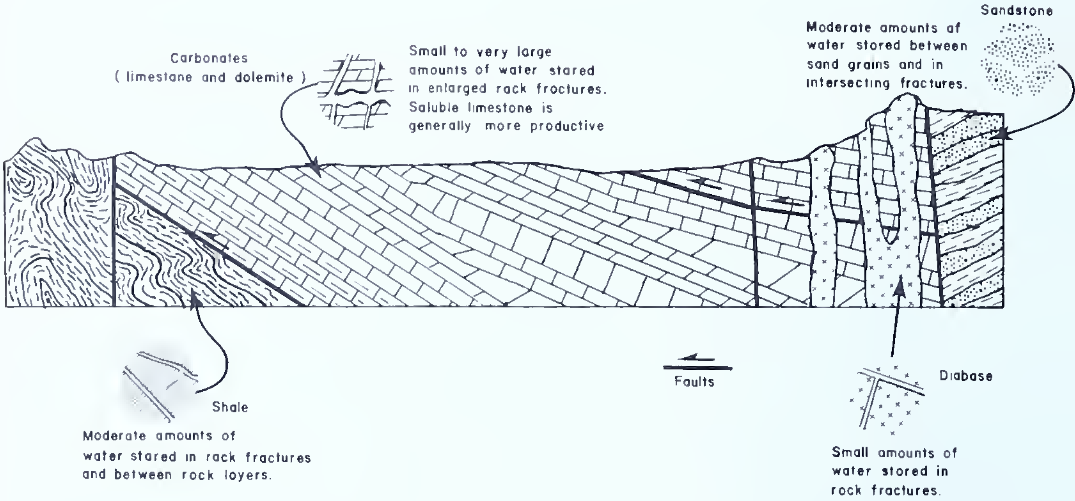
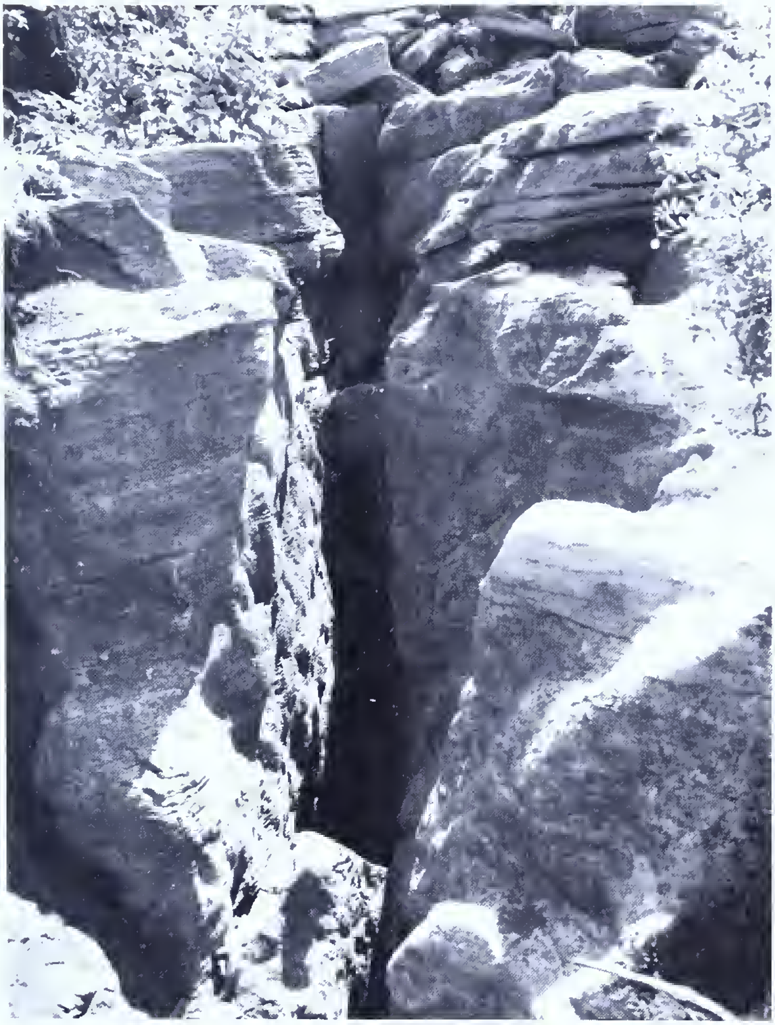

Carbonates
(limestone and dolemite)
Small to very large amounts of water stored in enlarged rock fractures. Soluble limestone is generally more productive
Moderate amounts of water stored between sand grains and in intersecting fractures.
Sandstone
Shale
Moderate amounts of water stored in rock fractures and between rock layers.
Faults
Diabase
Small amounts of water stored in rock fractures.

Figure 4. Water-bearing properties of rocks in metro area

preservation of recharge areas, the prevention of pollution, depth to the water table, and potential yield of the aquifer.

In the Harrisburg area, as in most of Pennsylvania, ground water occurs largely in fractured bedrock under water table conditions. Plates 6 and 7 are laced with lines, called fracture traces which delineate long, narrow zones of highly fractured rock. In these zones the fractures are more numerous and more open than in the adjoining rock. Wells penetrating fracture traces produce significantly more water than wells in the adjacent, solid bedrock. This is especially true in limestone areas where a well in a fracture trace will yield 500 gpm while another well 50 feet away in solid bedrock will be dry. Because of the fractured nature of the bedrock, recharge areas are areas around individual wells or well fields and not a distant mountain. The recharge area is actually the entire surface of the ground with discharge points being individual wells, springs, and stream channels. The boundaries between one recharge area and another for particular discharge points are represented by ill-defined and often transient groundwater divides on the water table. To further complicate this picture, the systems of fractures and solution openings present in the aquifers of the Harrisburg metro area are very complex and not all of them are hydrologically connected.

Water levels in adjacent wells may not be at the same elevation unless the bedrock fractures are interconnected. The depth to water table information is based on the assumption that, for the most part, there is at least a minor amount of interconnection of the joints and



Complex, open fracture system in the St. Paul Limestone, Hampden Township, Cumberland County.

fractures in the bedrock. Occasionally a well will be drilled which does not intersect these fractures. The water level in this well may not reflect the general depth to water in the area around it.

Figure 5 shows the hydrographs of three representative wells in the metro area for which several years of record are available. An annual cyclic water-level fluctuation in which the water level is highest in the spring and lowest in the fall is readily seen. These records do not, yet, reflect a long term decline of the water table.

Urban and suburban development will play a major role in disrupting the natural groundwater recharge-discharge system. By replacing the tree and grass cover with streets, parking lots, buildings

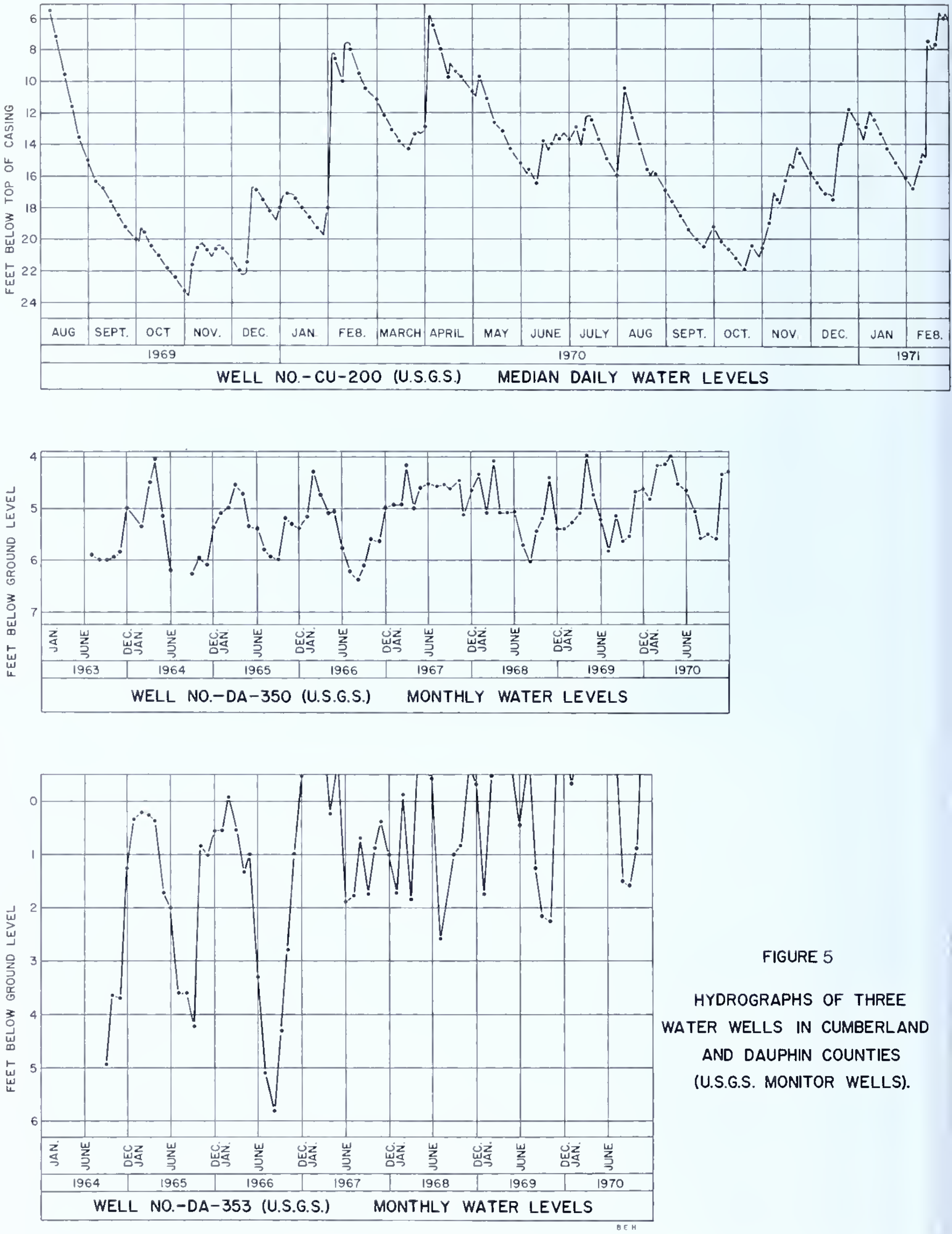


FIGURE 5

HYDROGRAPHS OF THREE WATER WELLS IN CUMBERLAND AND DAUPHIN COUNTIES (U.S.G.S. MONITOR WELLS).

and channeling precipitation into storm sewers, the aquifers are deprived of needed recharge. The long-term net result may be a decline in water levels and a deterioration of water quality. Monitor wells, such as those mentioned in Figure 5, are important so that we may keep a watchful eye on this increasing conflict between urbanization and aquifer recharge.

Pollution of our existing ground-water supplies is an increasing problem today. The modes and types of pollution are many. In settlements outside of the main core area of Harrisburg, Steelton, New Cumberland, Camp Hill, and Lemoyne, heavy past use of on-lot septic systems has severely damaged the local groundwater supplies. In time, the heavily polluted ground water of areas where public sewerage has been installed such as Linglestown and Hummelstown will be renovated by the beneficial effects of continuous ground water filtration, dilution and circulation. Industrial pollution is another matter; some toxic fluids such as phenol, for example, are virtually indestructible and can remain in the ground water system for an indefinite period.

Other problems attributed to ground water are persistent high water tables that respond rapidly to increased rainfall and surface discharges of water. Some of these areas are shown on Plate 6. This problem is common in carbonate rocks that have a very high permeability and porosity and low topographic relief. Low drainage areas in these rocks are characterized by recurring high water levels that can be hazardous, expensive and annoying. Another problem caused by ground-water circulation and water-level fluctuations in carbonate rocks is the development of voids, sinkholes and other solution features. These conditions are discussed in the engineering section of this report.

As the Harrisburg metro area urban sprawl expands, increasing demands will be placed on ground water. Careful planning will be required to protect the quality and quantity of these aquifers for generations to come. These waters are not unlimited. They can be over-pumped, virtually mined, and ultimately dried up or made totally unfit for any use. We will certainly need this supply in the Harrisburg metro area at some point in the future, and it must be protected.

Future Water Supply Alternatives

From wells

Advantages:

1. Use is usually near sources
2. Low treatment costs
3. Low capitol investment
4. Does not require filtration
5. Constant water temperature
6. Less vulnerable to national disaster
7. Less affected by drought
8. Compatible with many other land uses

Disadvantages:

1. May not be available in large volumes
2. Prediction of volumes available has much uncertainty

From Streams

Advantages:

1. Large volumes available
2. Impounding water can increase volumes available
3. Easy to predict precise volume available

Disadvantages:

1. Usually far from needs
2. Readily susceptible to pollution
3. Capitol investment high
4. Treatment costs high
5. Seasonal and drought variations
6. Not compatible with most other land uses

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MINERAL RESOURCES

General

Our standard of living can be directly correlated to the development of our mineral resources. Likewise, our future affluence is dependent upon the continued availability of these mineral resources. In planning for this future, we must keep in mind that mineral shortages come not only from mineral deposit exhaustion, but also from their unavailability at reasonable cost.

Industrial minerals, particularly shale, sand, gravel, dolomite, limestone and sandstone have direct application in construction.

Since these are high volume, low cost per ton, basic construction materials, the economics of transporting them are critical. Transportation restrictions change with supply and demand, but a radius of 50 miles from the source site is often used as a practical limit.

The mineral industry of the Harrisburg metro area supplies the local construction and steel industry. Metallurgical-quality limestone has been quarried for the steel industry in Steelton for many years, in addition to some of the stone being used as a source of aggregate.

Diabase, brown sandstone, and some limestone have been used periodically for building stone. The quarrying of clay and shale for the manufacture of ceramic products is increasing in Pennsylvania. Shale suitable for the manufacture of light-weight aggregate, brick, and tile are present.

Sand and gravel deposits have been excavated along the east shore of the Susquehanna River and in the higher-elevation terrace deposits, particularly in the Highspire area of Dauphin County. Plate 5 shows the distribution of these surficial (sand and gravel) deposits. Some of these sand and gravel deposits remain for exploitation, but limited reserves and urbanization are drawbacks.

Limestone used in constructing Founders Hall, Hershey, Dauphin County.

An inventory of quarry operations shows the following breakdown of actual sites (see Plate 5):

1. Five limestone/dolomite quarries supply crushed stone, aggregate and concrete
2. One shale quarry for brick
3. Two borrow pits for fill

Additional small borrow pits not detected during the inventory may operate on short-term and intermittent basis.

A tabulation published by the U. S. Bureau of Mines (Cooper, F. D., 1975) gives the value of mineral production for Cumberland and Dauphin Counties for 1972.

Cumberland	$2,998,000.00+	limestone, sand and gravel, clays
Dauphin	$3,102,000.00	limestone, sandstone, coal

Minerals Future

Readily available

Carbonate rock for concrete aggregate, crushed stone and possible building stone will continue to be an important construction commodity in the metro community. Large reserves of this rock still remain under agricultural and low-density settlements (see Plate 5). Metallurgical-grade, high-calcium limestone is also available and is the most desirable of the limestone formations in the area; as limited and important as this resource is, its future availability should be protected.

Shales suitable for brick manufacturing are in large supply in the areas north and south of the limestones. Considerable amounts of suitable diabase and sandstone are available as a building stone. Limited supplies of sand and gravel are available along the east side of the Susquehanna River and on some of the larger islands in the river, (see Plate 5).

The production of light-weight aggregate is possible from the shales of the Martinsburg and Gettysburg formations. Test data from a sample (Site No. 148B-Sh-8, Plate 5) of red shale collected in York County indicates that this rock (at least at the sample site) is a possible raw material for expanded aggregate. All currently available test information may be found in O'Neill (1965), Hoover (1971), and Lapham and Hoover (1971).

Agricultural, residential - industrial or mineral extraction land use — A confrontation ahead

Only recently, the real impact of a conflicting land demand by agriculture, mineral industry, heavy industry, and home builders has become important. In the Harrisburg metro area, the level land on limestone and dolomite bedrock is prime agricultural land, but it also contains a valuable mineral resource. It is craved by most builders and industry, and in addition, highway planners desire a portion of these level corridors.

The limestone sections of the metro area, already densely populated, are virtually lost to agriculture; and in most cases, they have become economically or environmentally unfeasible for quarry operations. The outlying areas are the essential ones for which the planners and government decision-makers must set priorities.

The economic limitations placed on moving low-value/high-weight/large/volume products such as crushed stone are well established. It therefore follows that all available rock material should be extracted prior to encirclement or cover by urbanization. The concept of multiple-land-use should be followed.

Most home owners do not welcome a quarry as a neighbor. Their main objections are dust, noise, increased heavy-truck traffic, and scenic degradation. In many cases dust, noise and scenic problems are minimized by the quarry operator through dust- and noise-control measures and natural beautification practices, but conflicts still arise between these quarries and their urban neighbors. Such confrontations may result in local statutory regulations which limit working hours and quarrying procedures. hich can provide

Active quarries and potential quarry sites are continually being encroached upon. This dilemma tends to force quarry operations to remote areas, which increases transportation costs, which in turn is a large part of the total cost of the product. The long-range effects of continued urban growth with quarrying limitations must be considered in regional planning.

The demand for construction minerals is increasing. Continued restrictions on quarrying will limit the supply of low-cost stone and reduction in production or increase in price may retard growth.

The rapid conversion of agriculture land for development purposes is another matter. Quarry sites use up a relatively small amount of surface area in relation to the amount of material removed. On the other hand, urbanization of agriculture land uses vast amounts of area for a relatively small number of people.

Hempt Bros. quarry with Green Lane Farms development in background, Lower Allen Township, Cumberland County.

Abandoned quarry site uses

Abandoned quarry sites are variously shaped, deep holes in the ground. Smaller "borrow pits" are scattered about the shale, siltstone and sandstone areas north and south of the limestones (Plate 5). The "borrow pits" usually take the form of a "bite" into the side of a hill. If need be, it is possible that these sites could be returned to their former natural shape, as is now required of most operating quarries by the "All Surface Mining Act" (Act 147 of 1971).

Most of the abandoned limestone quarries are filled with water to a level that is usually the elevation of the local, prevailing ground water table. Borrow pits, on the other hand, are almost always dry because they usually do not penetrate the water table.

The abandoned mines, quarries and borrow pits may well have secondary and sometimes tertiary use-potential: for example, quarry (primary use), sanitary landfill or water reservoir (secondary use), park area (tertiary use).

In the past, informal uses of "wet" quarries were for water sports, boating, fishing, and other outdoor recreation; dry quarries became the city or town "dump" and large borrow pits adjacent to major highways were conveniently leveled for commercial and industrial structures. But these were casual, fortuitous situations which had little or no planning consideration associated with them.

The major quarries in the study area, abandoned or active, are located on Plate 5. The deep mines in the Annville limestone belt of Dauphin County were abandoned because of the high cost of

One of the "old" Annville limestone quarries, Hershey, Dauphin County.

pumping out water to lower the ground water level from the working areas of the mines. Two of these are located in the project area. The depths of these mines and amount of ground water flowing into them allows them to be used at the present time as industrial and public water supplies and reservoir sites. Several other abandoned quarries are currently being used as public or private water supply reservoirs.

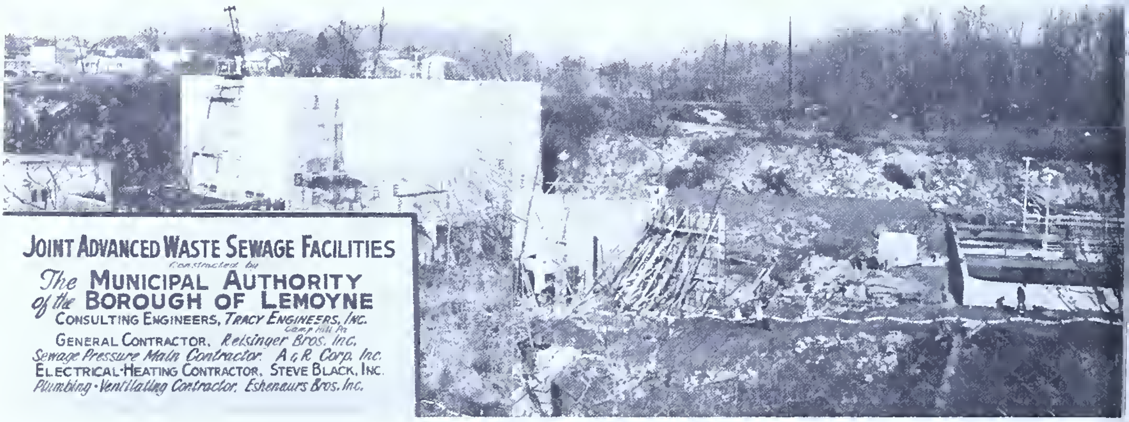
Abandoned limestone quarry used as public water supply reservoir, Paxtang, Dauphin County.

An alternate use for dry, abandoned quarries is as a site for the disposal of solid wastes. Permits for sanitary landfill sites are now required by Act 241 (Pennsylvania Solid Waste Management Act) in order to insure that adequate safeguards will be taken to protect ground water and land surface quality.

New experimental work and actual operations (Fergusson, 1974) are underway elsewhere in Pennsylvania where solid wastes have been placed into deep, abandoned, wet quarries that have been pumped dry and will be maintained in a dry condition by use of pumps and impervious quarry-wall membranes. If these operations succeed, future quarry sites and abandoned, unused quarries may be utilized to supplement the incinerator system for use by a large part of the Harrisburg metro area.

Bethlehem Steel Corporation quarry in the Annville limestone belt of Dauphin-Lebanon Counties.

Dry quarries and those that could be easily maintained dry at lowest cost are economically attractive, particularly if they are located in high-density or prospective high-density areas. It might be economically feasible and technically sound to use these particular quarries as the excavated element of a structure. The storage capability of a large quarry, several hundred feet deep and divided into usable floor space for utility equipment, auto parking or office space might be a highly useful, convenient and profitable venture. Abandoned, deep, dry mines in other parts of Pennsylvania are now used for such diverse operations as storage of valuable documents and mushroom growing.


JOINT ADVANCED WASTE SEWAGE FACILITIES
Constructed by
The MUNICIPAL AUTHORITY of the BOROUGH OF LEMOYNE
CONSULTING ENGINEERS, TRACY ENGINEERS, INC.
Camp Hill Pa
GENERAL CONTRACTOR, Reisinger Bros. Inc.
Sewage Pressure Main Contractor A & R Corp. Inc.
ELECTRICAL-HEATING CONTRACTOR, STEVE BLACK, INC.
Plumbing-Ventilating Contractor Eshenaurs Bros. Inc.

Waste sewage facilities for the borough of Lemoyne being constructed within a former limestone quarry.

The multiple-use concept is not new, but it is not used often enough. In addition to the technical, day-to-day quarry operations, quarry site selections for reserves and the quest for quality and transportation advantages, management must now also consider conflict with other priority land uses, planning for secondary and even tertiary uses, pollution prevention and aesthetic quality. All of these factors must be considered before any overburden is lifted from the bedrock.

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ENGINEERING CHARACTERISTICS OF THE ROCKS

General

Most construction is placed on or into bedrock. In some of the limestone areas, light structures may be placed in the residual soil, but in most of the report area, structures are attached to bedrock and the bedrock becomes the primary target of concern.

Rock properties such as cleavage, jointing, faulting, and solution openings are dominant in the upper 200 feet of the earth's crust. Engineering works are almost always concerned with this relatively thin surface zone.

When heavy and complex structures such as tunnels, dams, atomic reactors and high-rise buildings are planned, designed and constructed, many engineering rock characteristics must be considered, including rock strength, ease of excavation, and foundation quality (see explanatory legend accompanying Plate 7). The important factors to be considered in any construction are public safety, cost and construction efficiency.

As the demand for land increases, the most desirable portions get used up first, and then the planner must carefully select land uses that are compatible with the remaining countryside, avoiding major construction on or near naturally hazardous locations with unstable slopes, slide-prone rock areas, flood plains, sinkhole terrain and other adverse conditions.

Plate 7 and the accompanying descriptive legend show the selected engineering characteristics that apply to the different rock types exposed in the metro area. The map groups rock types by similar properties and not as individual geologic formations. In addition, rock joints (a type of fracture), cleavage and fault data are included.

The purpose of Plate 7 is to enable the reader to assign a group of engineering characteristics (Plate 7 legend) to rock types in geographic distribution. These are general characteristics subject to variation both laterally and vertically, intended for regional planning. They are not meant to take the place of the detailed site investigations that accompany most engineering projects.

Special Engineering Geology Concerns in the Metro Area

Waste disposal systems

Waste disposal systems, solid and liquid, huge municipal and small household, are all affected by geologic conditions. Solid waste disposal and on-lot septic system suitability for most of the area (excluding Fairview Township, York County) have been studied and reported by the Tri-County Regional Planning Commission (1968, 1969). A deep-well liquid waste disposal report involving all of Pennsylvania has been published by the Bureau of Topographic and Geologic Survey (Rudd, 1972). Sewage and waste lagoon site suitability is currently under investigation by the Bureau of Water Quality Management, Pennsylvania Department of Environmental Resources.

Listed below are general comments concerning the relationships of geologic data and interpretations as they affect the waste disposal systems mentioned above.

Solid waste disposal sites. The evaluation of the metro area of Dauphin and Cumberland Counties for solid waste disposal sites developed by the Tri-County Regional Planning Commission (1968, 1969) is based entirely on soil characteristics (Plate 4) and related data as they affect a waste disposal site.

Limestone bedrock areas (Plate 7) are usually undesirable as solid waste disposal sites unless special engineering modifications are made to prevent leachate movement to the ground water. Depth to bedrock (Plate 6) is highly variable and the soil/bedrock interface is very irregular. Limestone rocks will provide virtually no filtering (or cleansing) effect on the leachate entering the ground water because of the lack of primary porosity and because of permeability and composition of the rock. The availability of large amounts of secondary permeability through joints and other fractures and voids may accelerate rapid pollution of the ground water. If open quarries in limestone bedrock are to be considered for use as solid waste disposal sites, the bedrock must be covered with an impervious membrane and leachate-gathering and purifying equipment must be installed. As noted previously, a membrane installation in a large, deep, abandoned quarry in Montgomery County, Pennsylvania, began operations during the summer of 1971 (Fergusson, 1974).

If slope (Plate 2) and groundwater level (Plate 6) conditions permit, the best sites for solid waste disposal are found in the interbedded shale, siltstone and sandstone areas located north of the limestone belts (Plate 7). Limitations for landfill sites exist on slopes in excess of 15 degrees (Plate 2) and in areas where the high water table is less than 6 feet below the bottom of the lowest refuse lift (deposit of solid waste). Many of the shaly portions of these rocks weather deeply and are usually acceptable as cover material. Ground water levels are usually 20 feet or more below land surface (Plate 6) in the uplands and could provide substantial areas which would conform to minimum requirements of the Pennsylvania Solid Waste Management Act.

Most of the red-bed areas located south of the limestones (Plate 7) are considered undesirable for solid-waste sites. Slopes are moderate to steep (Plate 2) and the terrain is deeply dissected. Water levels are usually close to ground surface (Plate 6) and the soil cover is thin.

The diabase and "baked zone" bedrock areas are unacceptable for solid waste because of the extremely variable rock weathering depths, unually very thin soil cover, boulder fields, difficult excavation characteristics and steep slopes.

On-lot septic systems. This method of sanitary waste disposal is largely a function of the suitability of the soil (Plate 4) and the ability of the weathered bedrock to accept the effluent.

Again, the areas underlain by limestone bedrock are not recommended for this waste disposal system because of the pollution danger to the ground water and inability of the system to function properly.

Pennsylvania law (Act 537) requires a minimum of four feet of suitable soil to bedrock or water table (Plate 7) for on-lot sewage systems. In addition, soil permeability (Plate 4), land slope (Plate 2) (usually up to 8 percent limit), type of bedrock (Plate 5) and flooding potential (Plate 3) (by surface waters) are considered.

When all of these criteria are evaluated, the interpretation is that only a small portion of the metro area is considered suitable for on-lot septic systems (York County Planning Commission, 1971, p. 28 and Tri-County Regional Planning Commission, 1969, maps).

Derry Township sanitary landfill site in the Martinsburg Formation, north of the Limestone Valley.

Deep-well liquid waste disposal. A comprehensive report concerning the feasibility of deep-well liquid waste disposal in Pennsylvania has been published (Rudd, 1972). It concludes that the subsurface sedimentary rocks of the Harrisburg metro area are unsuitable for deep-well liquid waste disposal.

The structural and lithologic complexities of the rocks, the lack of reliable impermeable beds, the lack of discrete, potential injection zones, the minimal data available concerning ground-water movement and most important, the lack of deep, subsurface geologic information precludes the feasibility of any such operation in this area at the present time.

Sinkholes

The limestone and dolomite formations normally offer good foundation stability, but if inadequate site investigations are made,

Sinkhole in the fields east of Bullfrog Valley Road, Derry Township, Dauphin County.

serious foundation problems may occur. Solution cavities and the possibility of sinkholes are widely present in these rocks.

In the limestone valley of the Harrisburg metro area, solution becomes the dominant process in landform development. Subsurface drainage, sinkholes, disappearing streams and large collapsed depressions are all common features of this terrain. The limestones and dolomites of the area are particularly hazardous due to alternating beds of dolomite and limestone that are extensively faulted and jointed.

In addition to there being a serious problem with foundation stability, polluted water can quickly enter and spread through the aquifer. The common practice of adding raw sewage directly into solution conduits and the filling of sinkholes with trash and dead farm animals should be halted immediately.

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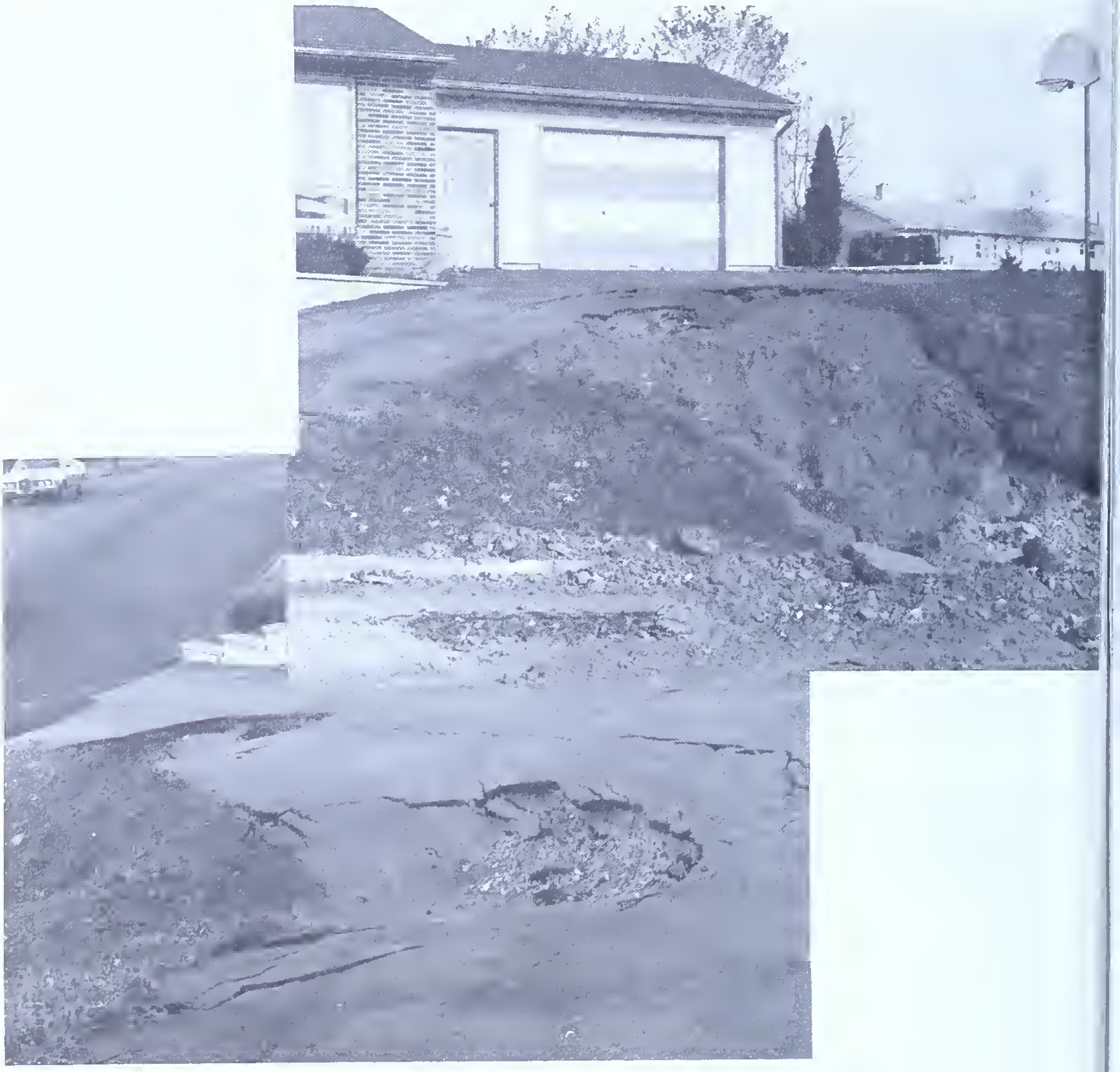

Sinkhole near the intersection of Route 422 and Middletown Road, Borough of Hummelstown, Dauphin County.

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SUMMARY

Living in harmony with the environment is a challenge. Before the delicate balance of nature is disturbed, all possible consequences should be considered.

This report represents an attempt to present geologic information in such a way as to be immediately useful to the people of the Harrisburg area. Environmental concerns are not a passing fancy of the 1970's but are here to stay. Society is and will continue to demand that we face these concerns and problems. We cannot restore all of the past nor do we want to preserve all of the present; it is a proper balance that we must strive for.

In summary, the following recommendations are offered for the Harrisburg metro area:

1. Existing geological information should be continually utilized in the planning process. Geologic data should be given a role in developing comprehensive land-use plans.
2. Municipal grading ordinances are a way to protect the land from indiscriminate earth-moving, and therefore should be developed.
3. Hard data on the projected needs of the metro construction industry and other user industries of rock materials should be developed and continually updated. These projected needs should be correlated to the availability of the mineral resource. Government, planning and industry officials should

put together appropriate land-use policy which would insure adequate supplies of the mineral resource while at the same time assuring maximum, effective use of the land surface. This may dictate that portions of the undeveloped metro area should be held in reserve for mineral extraction and agricultural use. The Annville high-calcium limestone is a unique mineral resource in the area and should be of prime importance.

4. It is recommended that the metro government determine safe yields of ground water per square mile or acre and that this information be correlated to present withdrawals in order that areas of overproduction and areas of underdevelopment may be spotted and management decisions made.
5. Flood-prone areas should be designated for open space, recreation, and temporary structures or facilities.
6. As additional, detailed, on-site geological information is needed in areas of rapid growth, planning and municipal officials should request or arrange for these geological data.

ACKNOWLEDGEMENTS

Information was gathered from many people and organizations during the preparation of this report. This material is cited in the references included in the text.

The authors are particularly grateful for the information and materials supplied by the following organizations: Bethlehem Steel Corporation, Steelton; Pennsylvania Department of Transportation District 8-0 Office, Harrisburg; Gilbert Associates, Reading; Kohl Brothers of Harrisburg; Pennsylvania Power and Light Company, Allentown; Tri-County Planning Commission, Harrisburg; UGI Corporation, Harrisburg; United States Geological Survey, Water Resources Division, Harrisburg; and the United States Soil Conservation Service, Harrisburg. Geological Survey colleagues Dr.'s Samuel I. Root, William D. Sevon, and Arthur A. Socolow critically reviewed the manuscript.

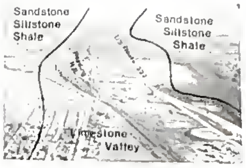
FOLD
OUT

TOPOGRAPHIC AND GEOLOGIC SURVEY
Arthur A. Socolow, *State Geologist*

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES

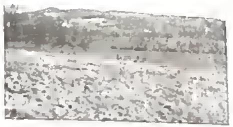
Farmland in Lower Swatara Township, Dauphin County

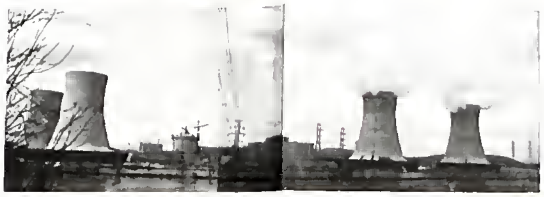
Round Top, part of the highlands in southern Dauphin County

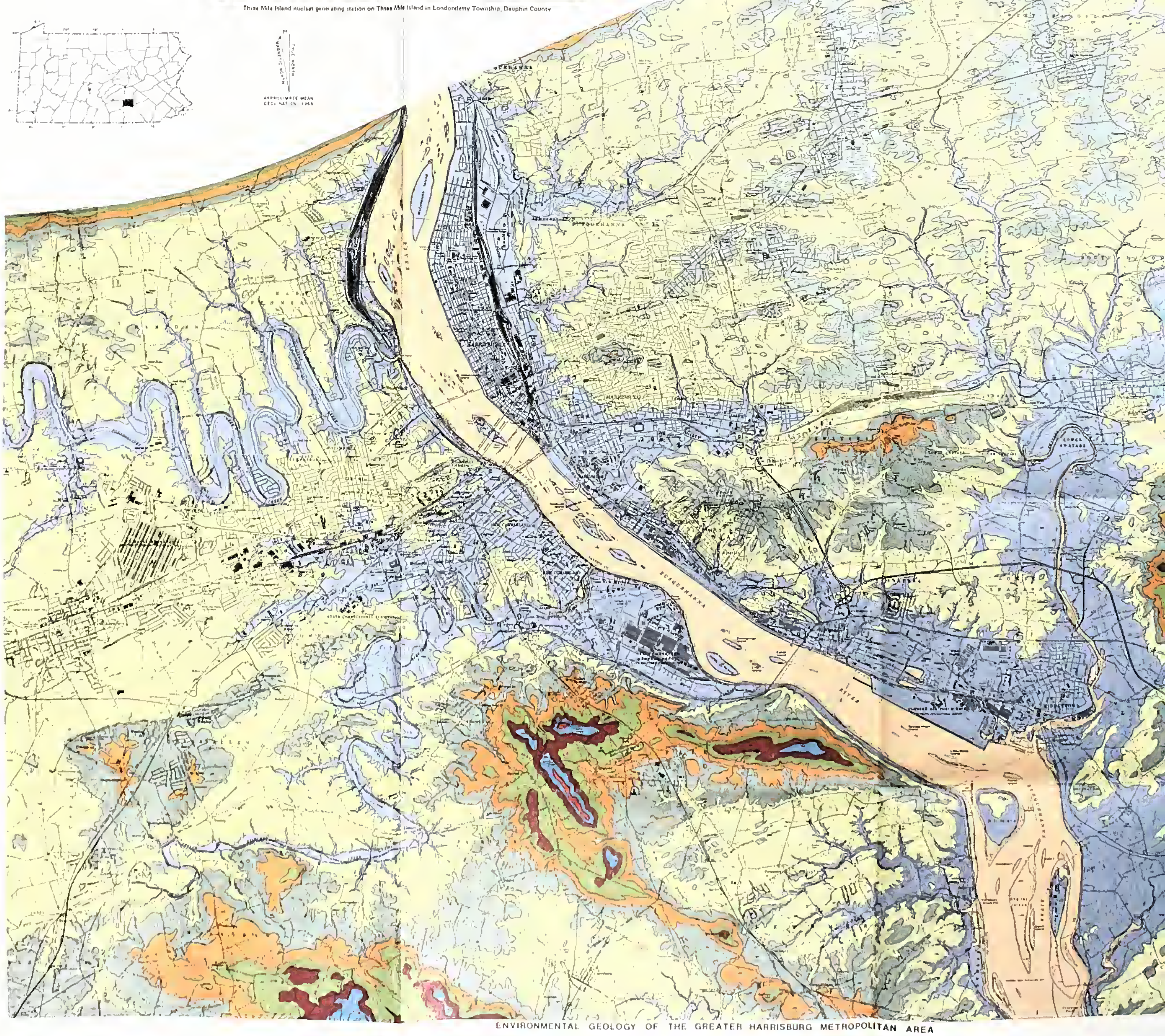


Small limestone valley north of U.S. Route 322 in Swatara Township, Dauphin County

Rockville Bridge in the Susquehanna Water Gap with Blue Mountain (left) and Little Mountain (right) in the background


"Diabase" ridges in background, Fairview Township, York County


Three Mile Island nuclear generating station on Three Mile Island in Londonderry Township, Dauphin County



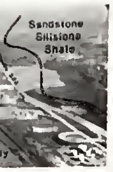
ENVIRONMENTAL GEOLOGY OF THE GREATER HARRISBURG METROPOLITAN AREA

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES

E G-4

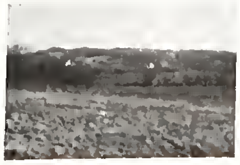
PLATE 1

PLATE 2 on back

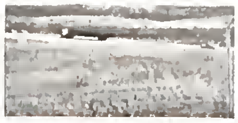


h of U.S. Route 322 in
County

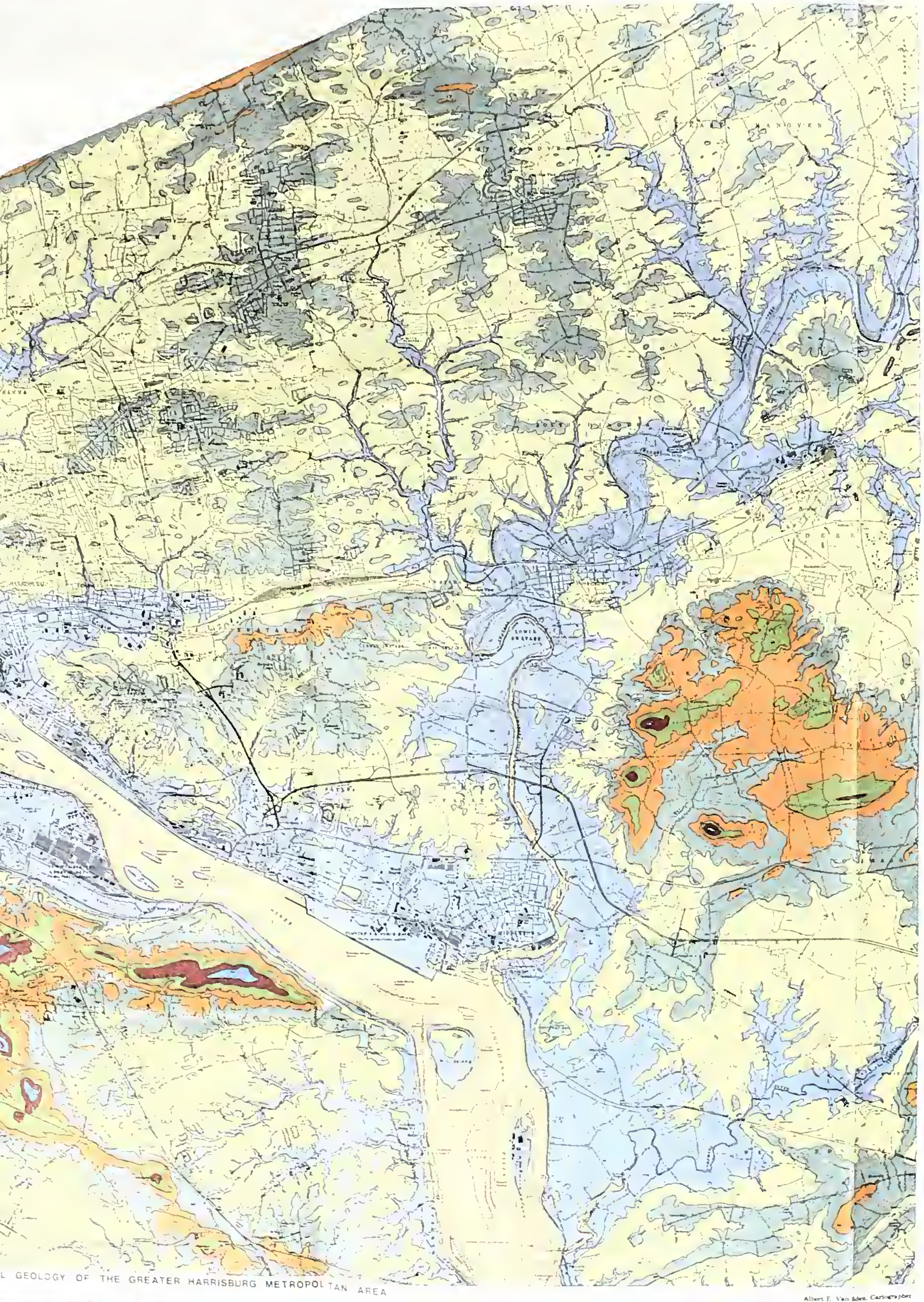
Rockville Bridge in the Susquehanna Water Gap with Blue Mountain (left) and Little Mountain (right) in the background



"Diabase" ridges in background, Fairview Township, York County.



Topography typical of the "shale" hills of the northern part of Cumberland County



L GEOLOGY OF THE GREATER HARRISBURG METROPOLITAN AREA

Albert E. Van Olden, Cartographer

EXPLANATION

UNDER 300 FEET	🟨	AREAL EXTENT: Includes the southern part of the Susquehanna River channel, Shelley Island, the shorelines of adjacent islands, and several small uncleared islands. SOIL COVER: Usually a sand and gravel base with no soil cover. USE: Primarily for recreation.
300-400 FEET	🟦	AREAL EXTENT: Comprises approximately 1/4 of the map area; relatively flat land adjacent to the Susquehanna River and major tributaries. Includes large areas of lowland where limestone is the bedrock. SOIL COVER: Thin in and immediately adjacent to the stream channels; fairly thick in areas underlain by limestone. USE: Suited to open space and recreation within flood plains; ideal for agricultural, industry and urban development outside flood plain areas.
400-500 FEET	🟨	AREAL EXTENT: Comprises about 1/2 of the land area in this report; low rolling hills underlain mostly by shale and limestone bedrock. SOIL COVER: Thin to moderately thick. USE: Suited to agriculture, industry and urban development.
500-600 FEET 600-700 FEET 700-800 FEET	🟦 🟧 🟩	AREAL EXTENT: Includes most of the land area in moderately steep slopes and narrow divides. SOIL COVER: Thin, more developed on shale and sandstone bedrock. USE: Well suited for certain types of agriculture, open space and limited urban development.
800-900 FEET 900-1000 FEET OVER 1000 FEET	🟥 🟦 🟥	AREAL EXTENT: Includes steep slopes and the tops of the highest hills in the area. SOIL COVER: Very thin soil cover on a variety of bedrock types including sandstone, conglomerate, diabase and "baked sediments". USE: Ideal for open space, wildlife, recreation and scenic vistas.

East Mall shopping center and I-83 have been constructed here in a small limestone valley of Swatara Township. The housing developments of Susquehanna Township in the background have been built on the higher shale hills adjacent to the valley.

Part of Harrisburg's uptown redevelopment section in the 1960's. Blue Mountain and Rockville Bridge crossing the Susquehanna are in the background to the north.

Looking east in the Great Valley of Cumberland County. Limestone quarry, center, is in Silver Spring Township.

Looking south across the limestone valley at Hershey

LAYERED RELIEF MAP

[illegible]

TOPOGRAPHIC AND GEOLOGIC SURVEY
Arthur A. Socolow, *State Geologist*

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES

The Conodoguinet Creek, Hampden Township, Cumberland County.

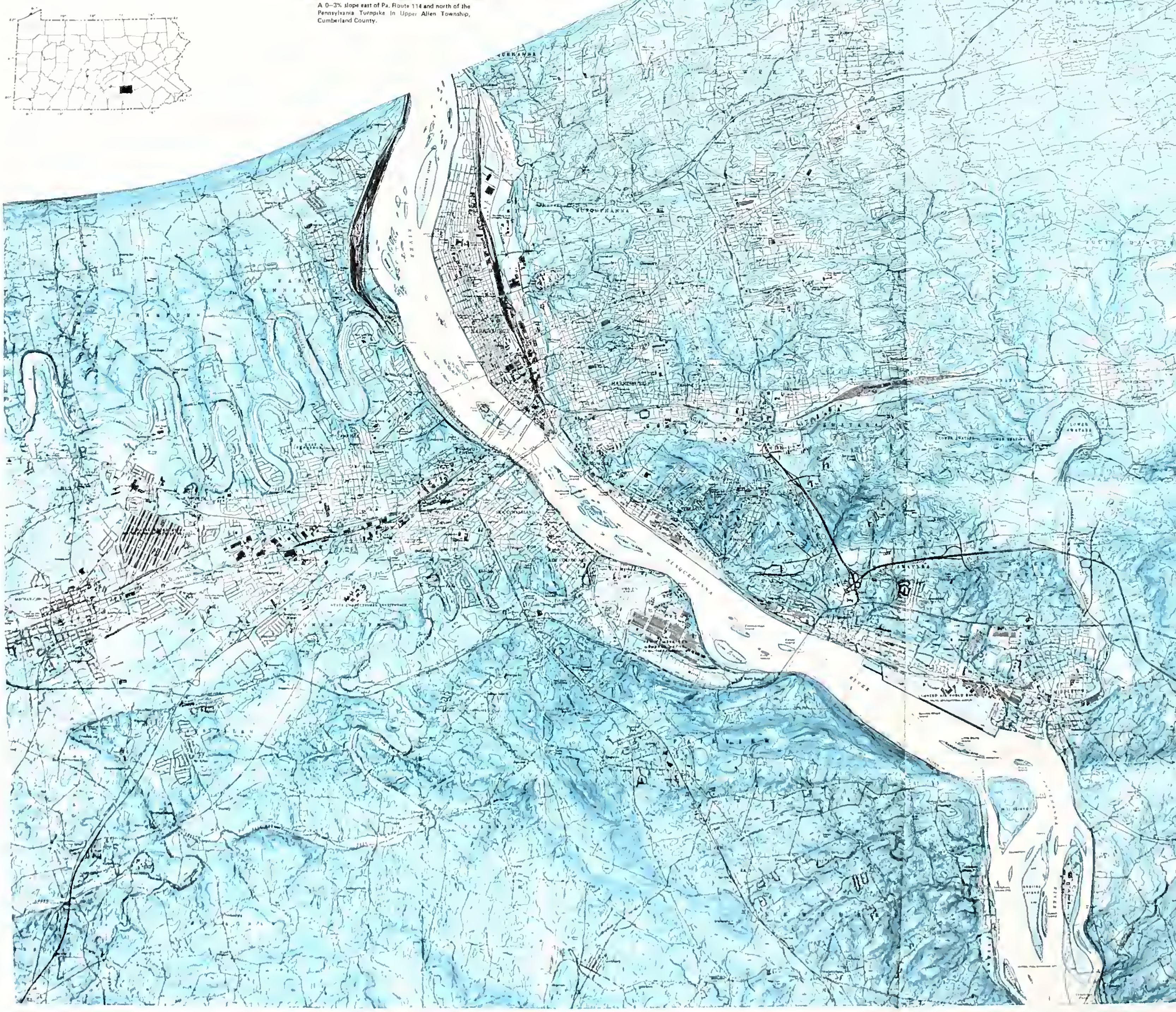
A 3–8% slope along Sears Run in Hampden Township, Cumberland County

A 0–3% slope in limestone terrain, Lower Swatara Township, Dauphin County

The Susquehanna River, the Rockville Bridge (background) and the George N. Wade Bridge (foreground)

Yellow Breeches Creek
Cumberland County

A 0–3% slope east of Pa. Route 114 and north of the Pennsylvania Turnpike in Upper Allen Township, Cumberland County.



ENVIRONMENTAL GEOLOGY OF THE GREATER HARRISBURG METROPOLITAN AREA

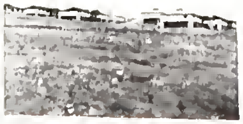
COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES

EG-4
PLATE 2
PLATE 1 on back

3% slope in limestone terrain, Lower Swatara Township, Dauphin
y.

The Susquehanna River, the Rockville Bridge (background) and the George M. Wade Bridge (foreground).

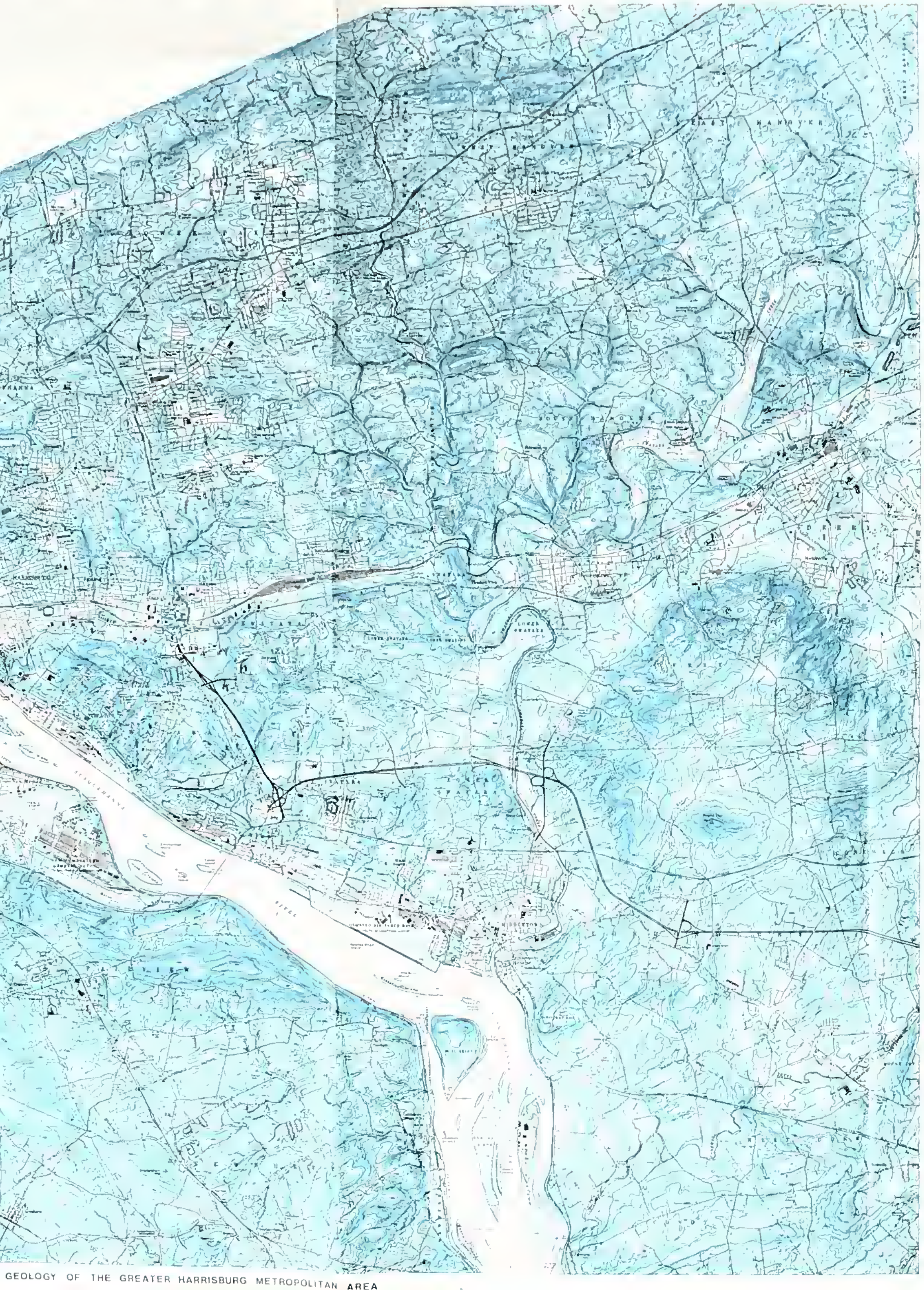
Yellow Breeches Creek, Upper Allen Township, Cumberland County.


Shale terrain of 3–8% slope, Susquehanna Township, Dauphin County.

Beaver Creek near Pleasant View Swatara Township, Dauphin County

Greater than 15% slope characteristic of the "diabase" ridges in Fairview Township, York County

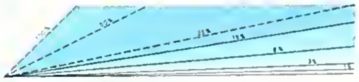
Swatara Creek at the Sand Beach bridge, South Hanover Township, Dauphin County.



EXPLANATION

A slope map shows the distribution of the degree of surface inclination and the slope is given in percent grade. Thus, an 8% slope or grade is 4.5 degrees of surface inclination measured from the horizontal or it is slightly less than 80 feet of vertical distance (elevation) for every 1000 feet of horizontal distance.

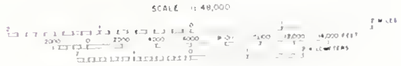
Slope information is important in all aspects of land use planning. It must be taken into account in the selection of transportation corridors, utility and communication line routes, in drainage and erosion control, in landside evaluation, in sewage disposal system design, and, in general, all modifications of the land surface by man which depend on the "lay of the land."



0-3%	Suitable for general urban development, agriculture, transportation corridors, commercial centers, open space, recreation, septic field systems and sanitary landfills. However, slopes of 1% or less may generate poor drainage conditions and flooding is possible adjacent to streams and rivers. Design and construction costs should be low depending on underlying rock material.
3-8%	Suitable for general urban and recreational uses, urban and interstate highway corridors, industrial parks and septic field systems.
8-15%	Suitable for general urban and recreational uses and conventional housing.
15%+	Suitable for general recreational use and highly engineered structures, site development limited, ideal for open space.

SLOPE MAP

SCALE 1:48,000



GEOLOGY OF THE GREATER HARRISBURG METROPOLITAN AREA

TOPOGRAPHIC AND GEOLOGIC SURVEY
Arthur A. Socolow, State Geologist

DEPARTM… OF PENNSYL…
…IRONMENTAL…

SUMMARY OF STREAM GAGING STATION DATA SUSQUEHANNA RIVER BASIN

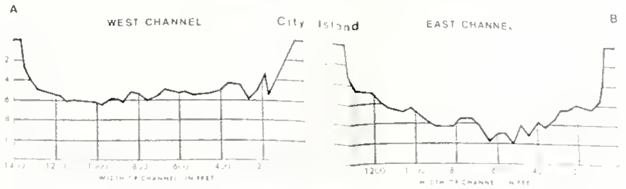
Station No.	Drainage Area sq. mi.	Average Discharge (Period of Record) CFS	Extremes of Discharge (Period of Record) CFS	Mean Discharge Water Year (1974) CFS	Remarks	Stream
1-5700	470	517	Max. 33,700 (6-23-72) Min. 24 (7-16-30)	644	Continuous periodically since 1911 to present	Conodoguinet Creek near Hogestown
1-5701	0.17	0.12	Max. 624 (6-22-72) Min. 0.01 (9-11-73)	0.16	Continuous since March 1967 to present	Conodoguinet Creek tributary No. 1 near Enola
1-5703	0.39	0.63	Max. 262 (6-22-72) Min. no flow on many days	.45	Continuous since Feb. 1967 to present	Conodoguinet Creek tributary No. 3 near Enola
1-5705	24,100	34,100	Max. 1,020,000 (6-24-72) Min. 1,730 (9-18-64)	29,330	Continuous since 1890 to present	Susquehanna River at Harrisburg
1-5715	216	212	Max. 15,900 (6-22-72) Min. 22 (9-12-66)	317	6/09 to 12/19 and 6/54 to present	Yellow Breeches Creek near Camp Hill

NOTES: 1. Water Year 1974 is October 1973 to September 1974.
2. References: U.S. Geological Survey, … Water Resources Summary for Pennsylvania, Water Resources Div., Harrisburg.
U.S. Geological Survey (1975) Water Resources Data for Pennsylvania, 1974, Part 1, Surface Water Records, Water Resources Div., Harrisburg, 331 p.

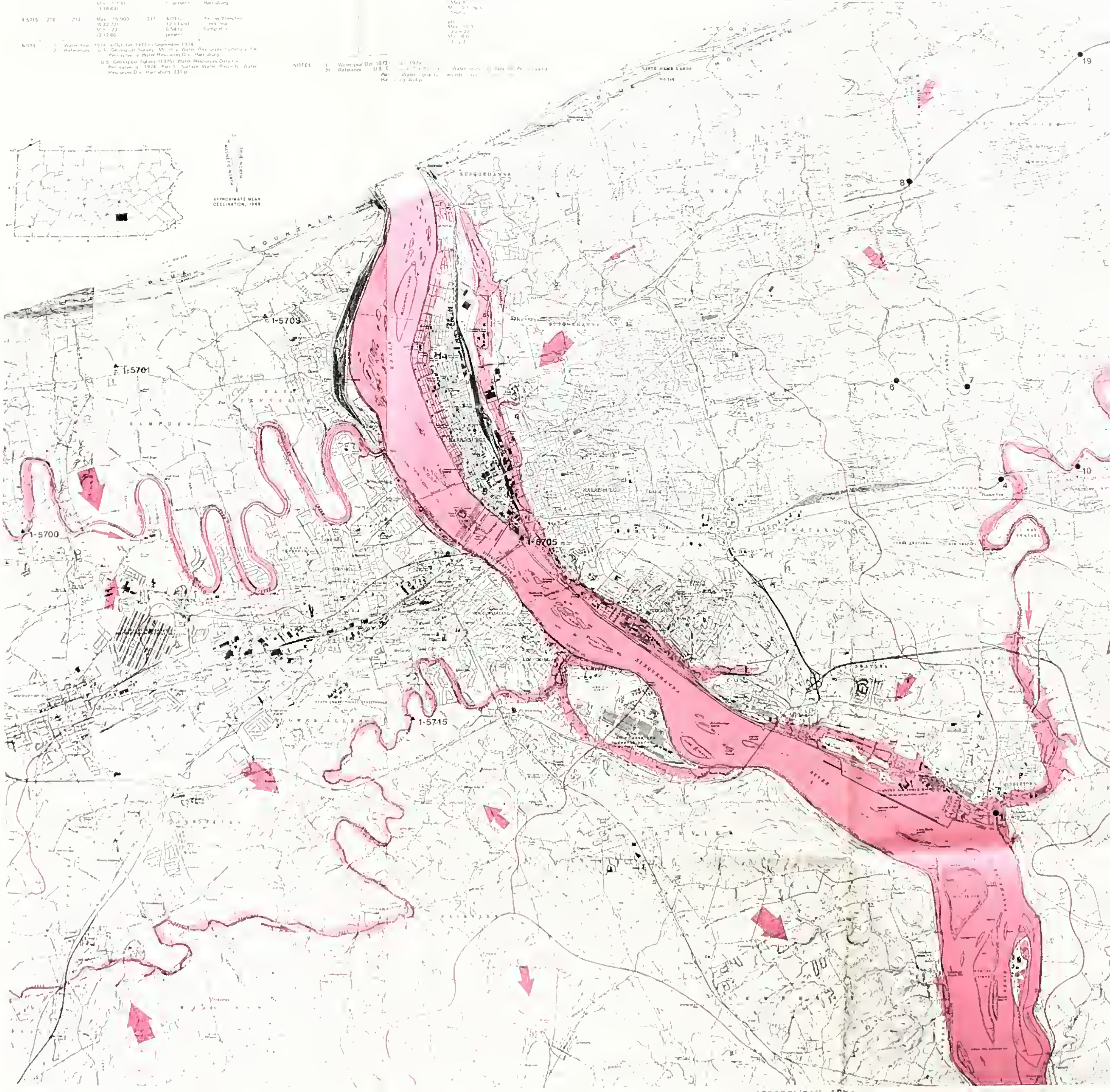
SUMMAR… SUS… …ALITY… BAS N

Station No.	…	Sediment concentra…	…
1-5701	Max. daily 70 JTU Sept. 13 Min. daily 1 JTU Oct. 26	Max. 190 m… Mar. 20 Min. 1 mg/l Oct. 26	
1-5703	Max. daily 450 JTU Oct. 29 Min. daily 4 JTU Oct. 21	Max. 1,020 Oct. 29 Min. 4 mg/l several days during Feb. and March	
1-5705	… not available		pH Max. 10.1 June 27 Min. 6.8 …

NOTES: 1. Water year Oct. 1973 … 1974
2. Reference: U.S. … Water resources Data for Pennsylvania, Part … Water quality records … Harrisburg, 404 p.

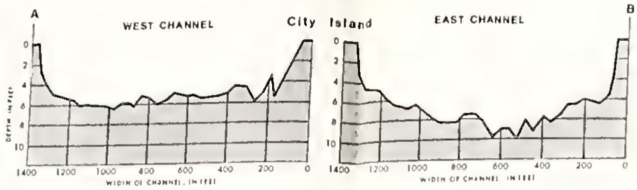


CROSS SECTION SHOWING DEPTH OF THE EAST AND WE… HANNELS, SUSQUEHANNA RIVER AT HARRISBURG OCTOBER 31, 1958 (After Anderson, P. W. 1963, … hemical haracter of the Susquehanna River at Harrisburg, Pennsylvania. U. S. Geol. Survey Water Supply Paper 1779-B …

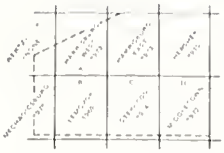


COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES

EG-4
PLATE 3
PLATE 4 on back



CROSS SECTION SHOWING DEPTH OF THE EAST AND WEST CHANNELS, SUSQUEHANNA RIVER AT HARRISBURG, OCTOBER 31, 1958 (After Anderson, P. W., 1963, *Variations in the chemical character of the Susquehanna River at Harrisburg, Pennsylvania*, U. S. Geol. Survey Water-Supply Paper 1779-B, 17 p.)



A [illegible] 1972 [illegible]

B [illegible] 1972, [illegible]

C [illegible] 1972 [illegible]

D [illegible] 1972 [illegible]

STATUS OF FLOOD-PRONE AREA MAPS PREPARED ON U.S. GEOLOGICAL SURVEY 7 1/2 MINUTE QUADRANGLE BASE MAPS

SUMMARY OF HYD[illegible] DATA IN THE SWATARA CREEK BASIN

A. Streamside location and drainage areas for some points of hydrologic significance in the Swatara Creek basin

Location No.	[illegible]	[illegible]	[illegible]
1	[illegible]	[illegible]	
4	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	
7	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	
13	[illegible]	[illegible]	[illegible]
16	[illegible]	[illegible]	
17	[illegible]	[illegible]	[illegible]
18	[illegible]		[illegible]
19	[illegible]		[illegible]
22	[illegible]	[illegible]	[illegible]

B. Measurements of streamflow in Swatara Creek basin
July 1, 1962 to June 30, 1963

Location No.	Date	Discharge (cfs)	[illegible]
1	[illegible] 1962	[illegible]	[illegible]
	[illegible] 1963	[illegible]	
	Mar 1 1963	[illegible]	
	[illegible] 1963	[illegible]	
	[illegible] 1963	[illegible]	
	[illegible] 1963	[illegible]	
4	Aug 24 1962	[illegible]	[illegible]
6	Aug 24 1962	[illegible]	[illegible]
7	Aug 24 1962	[illegible]	[illegible]
8	Aug 23 1962	[illegible]	[illegible]
10	[illegible] 1962	[illegible]	[illegible]
	[illegible] 1963	[illegible]	
	Mar 1 1963	[illegible]	
	Mar 8 1963	[illegible]	
	Mar 14 1963	[illegible]	
	[illegible] 1963	[illegible]	
13	Aug 24 1962	[illegible]	78
16	[illegible] 1962	142	[illegible]
	[illegible] 1963	[illegible]	
	Mar 1 1963	[illegible]	
	Mar 8 1963	[illegible]	
	Mar 14 1963	[illegible]	
17	July 30 1962	[illegible]	[illegible]
18	July 31 1962	[illegible]	
	Aug 2 1962	[illegible]	[illegible]
	Aug 24 1962	[illegible]	[illegible]
19	July 31 1962	3.0	10
	Aug 24, 1962	[illegible]	[illegible]
22	July 31 1962	[illegible]	16
	Aug 24 1962	[illegible]	16

C. Chemical analyses of samples from streams in Swatara Creek basin,
July 1, 1962 to June 30, 1963

Location No.	Discharge (CFS)	Date of Collection	Parts per million									
			Silica (SiO$_2$)	Iron (Fe)	Bicarbonate (HCO$_3$)	Sulfate (SO$_4$)	Chloride (Cl)	Nitrate (NO$_3$)	Alkyl benzene sulfonate (ABS)	Hardness as CaCO$_3$ Calcium, Magnesium	Specific conductance (micromhos at 25°C)	pH
22	0.4	9 27 62	—		138		5.5	·	0.01	118	213	7.0
	—	3 7 63	4.2	[1]0.81	34	6.1	6.0	7.0	—	36	117	6.4
18	3	9 27 62	—	—	40	4.2	2.0		0.03	33	60	7.1
16	142	10 29 62	—	—	84	59	9.6	—	0.12	137	325	7.2
	545	2 21 63	—	—	62	37				91	211	6.9
	771	3 1 63	—	—	70	39	—			103	262	[illegible]
	3,790	3 8 63	—	—	36	19			—	54	149	6.5
	3,040	3 14 63	—		40	25			—	61	165	6.6
13	35	9 20 63	—	—	215	31	16		0.10	212	491	7.4
10	173	10 29 62	—	—	105			—	0.11	144	343	7.5
	501	2 21 63	—	—	68	39	—			107	262	6.9
	335	3 1 63	—	—	66	42	—	—		128	356	7.2
	3,720	3 8 63	—		32	18	—			51	140	6.7
	2,380	3 14 63	—		42	24	—	—	—	63	168	6.8
8	—	9 27 62	—	—	102	0.0		—	0.04	92	211	7.6
7	3	9 27 62	—	—	121	—	9.0		0.04	116	278	7.4
1	175	10 29 62	—	—	96	51	9.0		0.12	148	340	7.4
	629	2 21 63	—	—	14	38				106	278	6.9
	302	3 1 63	—	—	88	41			—	120	301	7.3
	5,530	3 8 63	—		32	18	—		—	62	141	6.7
	3,910	3 14 63		—	43	24				65	171	6.9

[1] In solution when analyzed.

Reference: Stuart, W. T., Schneider, W. J. and Crooks, J. W., 1967, *Swatara Creek basin of southeastern Pennsylvania*, U. S. Geol. Survey Water-Supply Paper 1829, 79 p.

WATERSHED BOUNDARIES, DRAINAGE DIRECTION AND FLOOD-PRONE AREAS

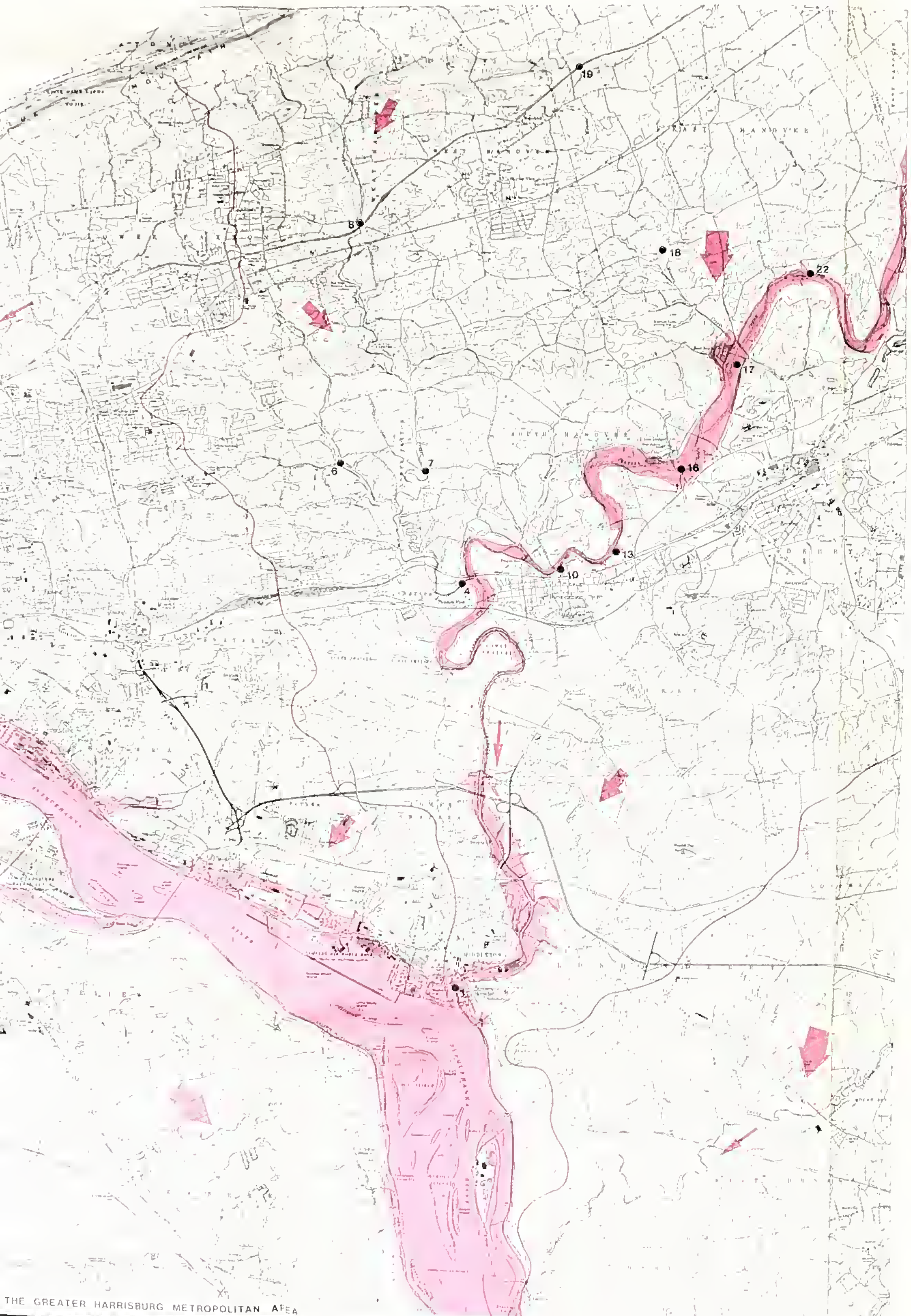
The areas surrounded by watershed boundaries are drainage basins, seven of which may be differentiated in this area, and whose streams ultimately empty into the Susquehanna River. All water originating as precipitation is gathered together within each basin and is contributed to a particular stream or system of streams. Thus, the boundaries delineate the areas of natural surface runoff between one stream system and another.

Drainage basin information is important in planning land development because data on the physical character of each basin enables estimates to be made on the runoff effects produced by storms of varying intensities.

Planners also need information concerning the flooding potential of an area. Any land that has been flooded in the past, may well be damaged again unless the problem has been controlled upstream.

Areas designated as flood prone have a 1 in 100 chance on the average of being flooded during any year. Smaller sections (not shown separately on the map) of the flood prone areas have a greater than 1 in 100 chance of being flooded during any year with some immediately adjacent to streams flooding almost annually (depth and duration of flooding are not indicated on the map). *Careful land-use considerations should be given these areas; they represent areas of high potential hazard.*

The height of a flood stage above any point is dependent on constant and variable factors. Constant factors include basin area, slope and shape; variable factors include intensity and distribution of rainfall, storm duration, groundwater table level, and the hydraulic characteristics of restrictions placed in the path of the flow.



THE GREATER HARRISBURG METROPOLITAN AREA

EXPLANATION

▨ FLOOD PRONE AREAS

∼ WATERSHED BOUNDARY

➡ DRAINAGE DIRECTION

▲1-5701 STREAM GAGING STATION
A gaging station is a particular site on the stream where systematic observations of gage height or discharge are obtained

●1 HYDROLOGIC DATA SITES IN THE SWATARA CREEK BASIN

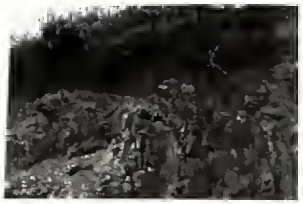
A B SITE OF CHANNEL CONFIGURATION

DRAINAGE AND FLOOD-PRONE AREA MAP

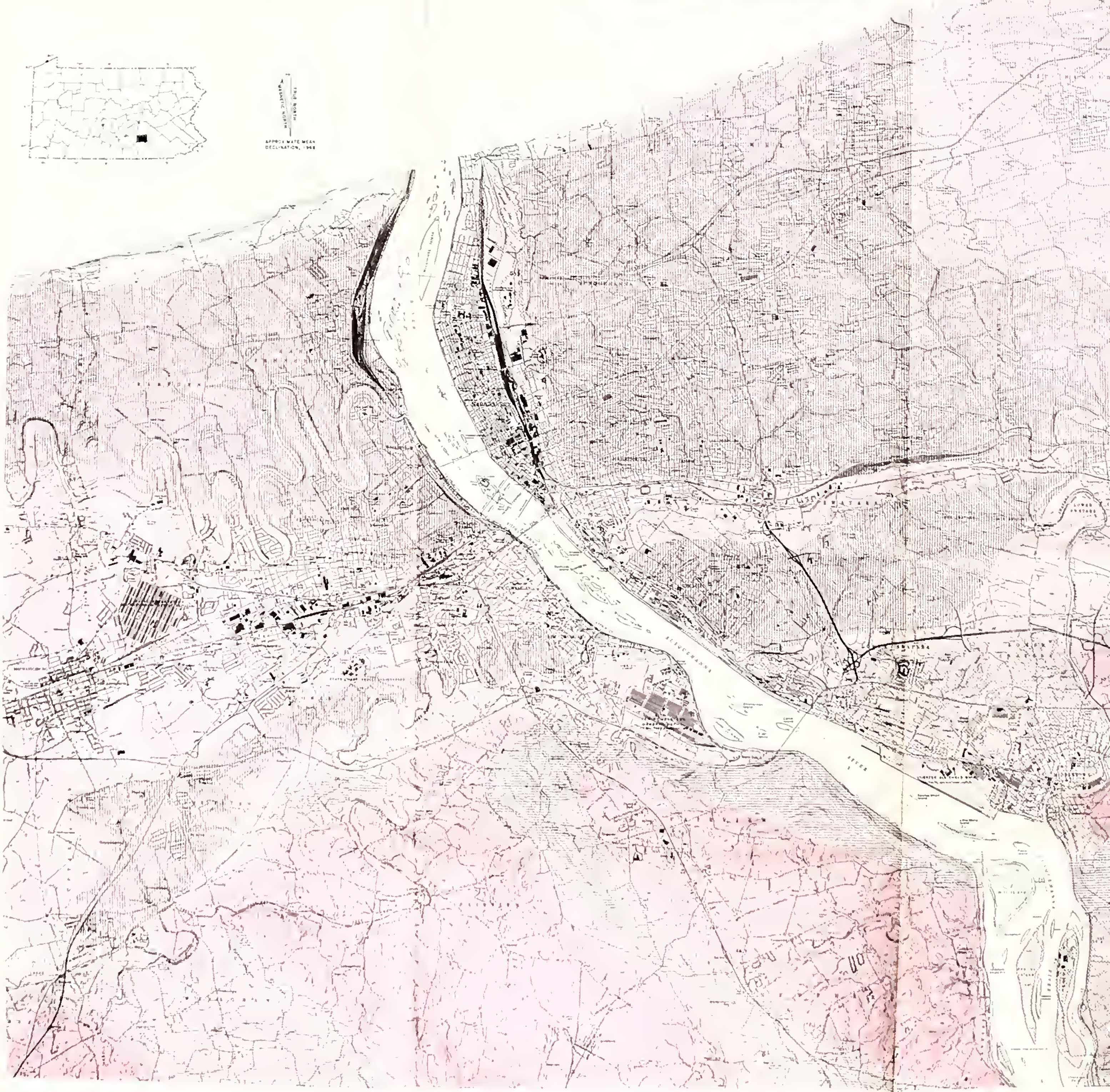
SCALE [illegible] 48[illegible]

TOPOGRAPHIC AND GEOLOGIC SURVEY
Arthur A. Socolow, *State Geologist*

COMMONWEALTH
DEPARTMENT OF ENVI


Soil profile in the Martinsburg shale, Lower Paxton Township, Dauphin County. Soil thins to less than 2 inches at the top right.

Variable and thin soil profile in the Gettysburg sandstone, siltstone and shale, Derry Township, Dauphin County.



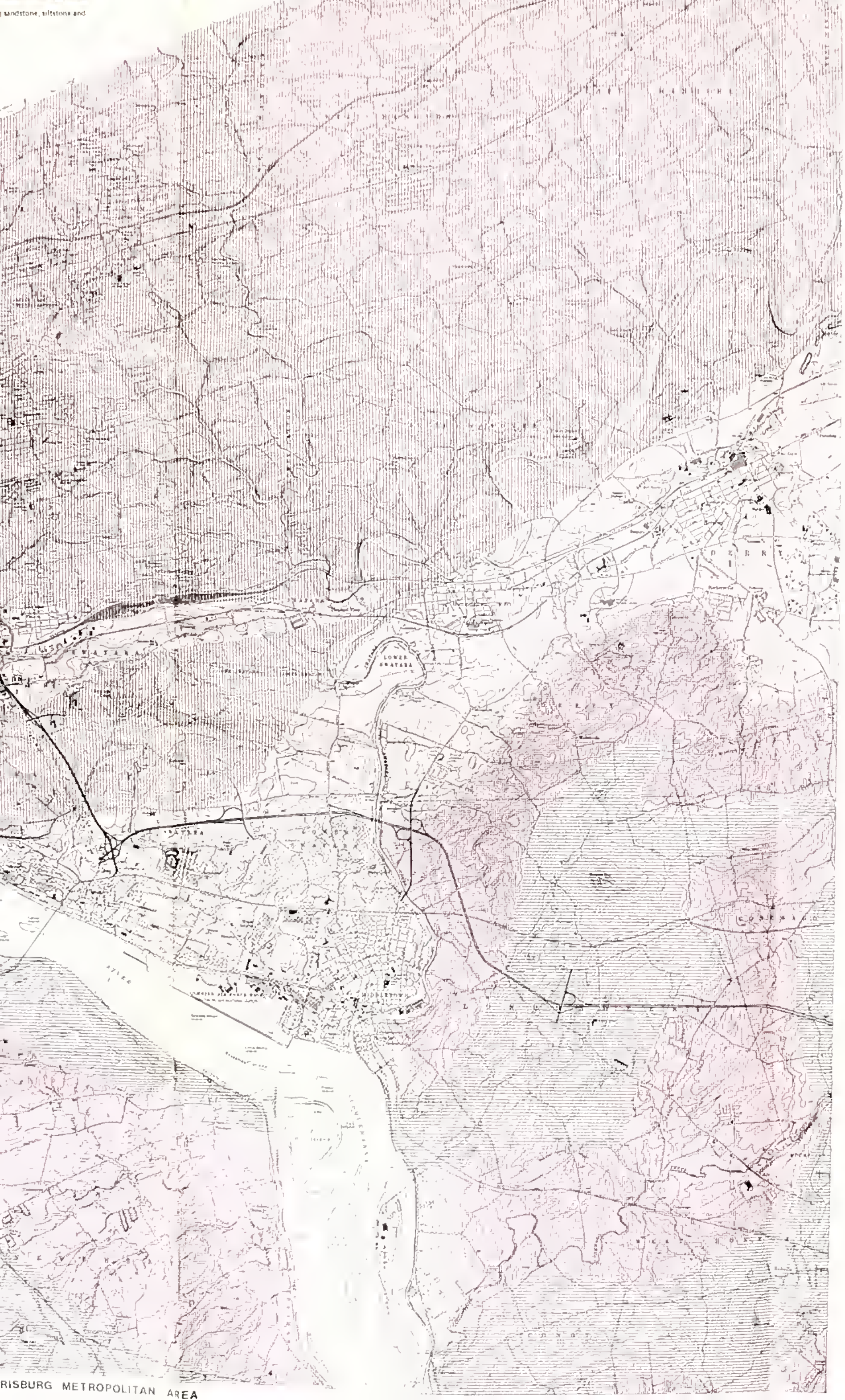
ENVIRONMENTAL GEOLOGY OF THE GREATER HARRISBURG METROPOLITAN AREA

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES

EG-4
PLATE 4
PLATE 3 on back

sandstone, siltstone and

Highly variable soil profile in the limestone and dolomite formations of the Hershey Valley



RISBURG METROPOLITAN AREA

EXPLANATION

A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil and is named for the major soils. A map showing soil associations is useful to people who want a general idea of the soils, who want to compare different parts of the report area, and who want to know the location of large tracts that are suitable for a certain kind of land use. This map is a useful general guide in managing a watershed, a wooded tract, a wildlife area and in planning engineering works, recreational facilities, and community developments.

☐

DUNCANNON CHAVIES TIOGA ASSOCIATION

Dauphin County and Susquehanna River areas of Cumberland County: deep, well drained, nearly level and gently sloping soils, on terraces and flood plains mostly along the Susquehanna River, soils are developed from sand, silt and clay underlain by gravel and sand, moderate to moderately rapid permeability, moderate to high available moisture capacity, in part subject to flooding.

Excellent for cropland, woodland, and recreation, severe limitation for septic fields and landfills.

☐

MURRILL CLARKSBURG ASSOCIATION

Deep, gravelly deposits from limestones, shales, sandstones, and quartzites, good surface drainage, average depth to bedrock 5 feet, moderate slope, in part slow permeability, seasonal high water table in some areas.

Good to excellent for cropland and woodland, moderate limitation for on site sewage disposal.

☐

BRECKNOCK NESHAMINY ASSOCIATION

Deep, well drained soils on ridges and higher elevations, associated with diabase and baked rock, grayish brown, brown, and yellowish red subsoil, slaty zones and areas with numerous large boulders on surface are common, clay loam and silty, clay loam subsoil, gentle to moderate slope, moderate available moisture capacity, moderately slow permeability, seasonal high water table.

Good to very good for woodland, fair to poor for general farming, severe limitation for on site sewage disposal, moderate limitation for recreation.

☐

LEWISBERRY PENN ATHOL ASSOCIATION

Deep and moderately deep, well drained, formed in material weathered from red sandstone and shale; sandy surface layer and reddish brown subsoil, gravelly, sandy clay loam to shaly, silty, clay loam subsoil, moderate available moisture content, gravelly, moderate to steep slope.

Fair to poor for cropland, good for woodland, moderate limitations for on site sewage disposal and recreational facilities.

▥

BERKS BEDINGTON WEIKERT ASSOCIATION

Deep to shallow, well drained, nearly level to steep soils, developed in material weathered from gray shale and sandstone, shaly silt loam to shaly, silty clay loam subsoil, gently rolling to steep landscape, moderate available moisture capacity, moderate to steep slopes.

Fair to poor for cropland, fair to very good for woodland, moderate to severe limitations for on lot sewage disposal and recreational facilities.

☐

HAGERSTOWN DUFFIELD ASSOCIATION

Deep, well drained, nearly level to gently sloping soils, tends to be shallow in areas where edges of limestone bedrock protrude the surface, formed from weathered limestone and dolomite, topography is undulating with numerous concave depressions, soil colors are yellowish brown to red, silty clay loam to clay subsoil, moderately permeable, high available moisture capacity.

Excellent for cropland and woodland, slight to moderate limitation for on lot sewage disposal, only slight limitations for recreational facilities.

☐

Areas of observed pinnacle weathering in carbonate rocks (Soil Conservation Service Cumberland County only).

DATA SOURCES

U.S. Department of Agriculture, Soil Conservation Service.

Kunkle, W. M., Lipscomb, G. H., and Kinnard, Richmond (1972) *Soil Survey, Dauphin County Pennsylvania*. U.S. Dept. Agriculture, Soil Conservation Service, 104 p., 73 maps.

Higbee, H. W. (1967) *Land Resource Map of Pennsylvania*. The Pennsylvania State University, College of Agriculture Experiment Station. Scale 1 inch = 6 miles.

Soil Conservation Service (1972) *General Soil Map of Pennsylvania*. U.S. Dept. Agriculture. Scale 1 inch = 12 miles.

SOIL ASSOCIATIONS MAP

SCALE 1:48,000

1 0 1 2 MILES
2000 0 2000 4000 6000 8000 10,000 12,000 14,000 FEET
2 1 0 1 2 KILOMETERS

TOPOGRAPHIC AND GEOLOGIC SURVEY
Arthur A. Socolow, State Geologist

GEOLOGICAL CLASSIFICATION					DESCRIPTION OF ROCK UNIT		MINERAL RESOURCES		ENVIRONMENTAL CHARACTERISTICS	
ROCK SYSTEM	AGE IN YEARS	ROCK GROUP, FORMATION AND NAME		MAP SYMBOL AND COLOR	THICKNESS OF ROCK UNIT	DESCRIPTION OF ROCKS TO AID RECOGNITION IN THE FIELD	PRIMARY USES	GENERAL CONSIDERATIONS	PRIMARY CONCERNS	GENERAL CONSIDERATIONS
RECENT ↓ TERTIARY	100,000		Surficial deposits composed of colluvial deposits and alluvial deposits including terrace gravels and sands	Qc Qal	Qc up to 50 feet thick, Qal maximum thickness of 30 feet	Qc - large angular blocks, moving by gravity from high positions along Blue Mountain and settling along the south slope Qal - clay, silt, sand and gravel, lensing, sometimes chaotic, size of this unconsolidated material usually grades from coarse on the bottom to fine at the top, deposits usually show bright and variegated colors	Construction Materials Sand and Gravel (- 20' thicknesses measured at specific locations in core holes and outcrops)		Compressible high water content water table generally near surface, subject to flooding	
TRIASSIC	195 million		Diabase and "Baked" Zones	Trd	Major sheets 800 2500 feet thick, thinner cross cutting bodies (dikes)	Diabase - igneous rock, medium to coarse grained dark gray, composed of the minerals plagioclase feldspar and black or green augite, unweathered rock is impermeable, non porous and very dense	Building Stone and Aggregate		Permeability very low poor aquifer very difficult to excavate, good cut slope stability excellent foundation for heavy structures	
						"Baked Zone" - metamorphosed shales and sandstones adjacent to the diabase, may appear "block like" in shale and is very tough; metamorphosed sandstone and conglomerate may be weak and incompetent.	Aggregate			
	180 200 million	GETTYSBURG FORMATION[2]	Gettysburg Formation (undifferentiated)	Trg	7800 10 000 feet thick	Interbedded red shale, red siltstone, red, brown and gray sandstone, brown and red quartz and limestone conglomerate, shale is thin to medium bedded, usually brittle with a hackly fracture sandstone varies from fine to coarse grained, usually the finer grained rocks predominate, conglomerates contain different rock type fragments and rock texture is highly variable	Building Stone (includes some unmapped sandstones in Trg area), Brick, possible Light-Weight Aggregate and Fill		Thin soil cover has tendency to creep downslope, potential slide plane at soil and shale/siltstone interface, swelling clays may be present fair to good aquifer weathered rock easily excavated fresh rock more difficult, poor cut slope stability good foundation for heavy structures	
			Sandstone[1]	Trgs	Unknown In dividual beds are up to 10 feet thick	Sandstone occurs in discrete bodies, the finer grained texture predominates Color varies from red to brown to gray Many of the more resistant sandstone units are brownish colored while the red variety seems to contain a highly weatherable clay "cement" and breaks down easily Sorting is very good in the fine grained sandstones but extremely poor in the coarse-grained units	Building Stone			
			Quartz Conglomerate	Trgqc	Unknown	Quartz conglomerate contains a brownish to reddish colored ground mass Pebbles may be up to 2 inches in length The iron stained groundmass may make up 50% of the rock The conglomerates are usually associated with larger bodies of sandstone, occasionally shale conglomerates will be found The quartz conglomerate is usually massive and bedding may be difficult to distinguish	Building Stone and Fill			
			Limestone Conglomerate	Trglc	Unknown	Most of the limestone fragments in the limestone conglomerate are rounded and may be up to 15 inches in length, may contain some shale fragments and quartz pebbles, matrix is red, sandy and calcareous Most of this rock unit is associated with the Triassic border contact	Building Stone and Decorative Facing Stone			
UPPER ORDOVICIAN	436 500 [illegible]	MARTINSBURG FORMATION	Martinsburg Formation (undifferentiated)	Om	Unknown	Mostly shale with minor amounts of siltstone and sandstone; unweathered shale, siltstone, and sandstone are dark gray to greenish gray, weathered material varies from brownish gray to reddish brown depending upon the intensity of the weathering Undifferentiated shale and siltstone located between carbonate outcrop belts is highly deformed, the rocks contain large amounts of quartz in veins, pods and thin stringers	Brick, possible Light-Weight Aggregate and Fill	Economics may require the use of locally available resources This geologic map may be used to determine a possible source of conflict between use of a site and use of the underlying rock Three aspects of land use unique to mineral production should be considered by local planning commissions and municipal governments: 1 The protection and conservation of known mineral deposits 2 The regulation of the extractive and processing operation 3 Reclamation and use of the site upon completion of the operation Quarries need not be just holes in the ground to be filled in They can provide the basis for other desirable uses A quarry area might be converted into a park, swim club, stadium, or safe target practice range *Multiple use of the land is always possible with the proper planning*	Low effective porosity and permeability, fair to poor aquifer, moderately easy to excavate with heavy power equipment, fair to good cut-slope stability, fair to good foundation for heavy structures, must be excavated to fresh unweathered rock	This geologic map can be used in the identification of certain geologic features which might adversely affect construction of buildings and highways. Failure to identify these features might give the impression that no problems exist For example, faults and connections between faults have been shown even though in some instances, conclusive evidence for their presence is lacking The geology of any region has the potential for unexpected environmental problems Thus it is important to define these hazard areas before construction begins Nearly all areas which combine moderate to steep relief, soft or weak bedrock, and high moisture content present the possibility of rock slides and mud flows Any construction work, changes in drainage or increases in the water content may activate such potential hazards This map may be used to determine the presence of outcrops which in turn would show that areas of exposed bedrock may be unacceptable for sanitary landfills
			Graywacke	Omg		Graywacke conglomerate is common with alternating beds of dark gray shale, siltstone, and sandstone Pebbles and blocks in the conglomerate include dark, fine grained limestone, red, black, and olive colored chert and gray, red, and green shale Most of the carbonate pebbles have been dissolved, leaving only holes in the rock	Fill			
			Sandstone	Oms		Massive bedded, sandy, conglomeratic limestone and calcareous sandstones	Fill			
			Limestone	Oml		Very thinly bedded limestone, platy weathering, very fine-grained, silty limestone	Fill			
			Red Shale	Omrs		Red shale, brittle, not associated with chert, weathers easily, not a ridge former	Fill			
			Shale and Mudstone (undifferentiated)	Omo		Red, maroon, purple and gray to black colored, brittle, fossiliferous, local units of white-weathering shale, siliceous shale and chert; manganese (bluish black) staining associated with chert, chert units hold up low ridges Chert indicated by XXXX	Fill			
			Basal Limestone	Ombl	400 feet	Limestone interbedded with shale and small lenses of conglomerate Shale and limestone dark gray, limestone beds 1/4 to 2 inches thick Conglomerate consists of well rounded limestone pebbles with a dark gray, calcareous siltstone matrix Shale and locally developed sandstones are calcareous	Fill			
MIDDLE ORDOVICIAN			HERSHEY FORMATION (LV)[3]	Oh Ohm	May be less than 20 feet thick, thins westward	Limestone is dark gray, argillaceous, thin bedded, grades upward into shales, weathers medium gray to yellowish gray	Fill		Solution enlargement of joints, cavern collapse or surface into channelways expressed as depressions or sinkholes on surface, almost anywhere in this report area where limestones or dolomites occur at the surface or in the subsurface, serious problems may be expected from solution opening cave ins, surficial drainage goes directly to groundwater system, high potential for groundwater pollution, highly irregular soil bedrock interface, differential soil compaction may be a problem, depths to bedrock may exceed 75 feet, excellent individual aquifers, some economically important high calcium limestone deposits excavation frequently requires blasting good cut slope stability foundation investigations are needed to determine existence or lack of subsurface openings	
			MYERSTOWN FORMATION (LV)	Omy	200-250 feet	Limestone is medium gray, thin bedded, black, graphitic limestone at base, weathers medium to medium-light gray with a bluish tint	Fill			
			CHAMBERSBURG FORMATION (CV)	Oc	650 feet	Limestone is argillaceous, cobbly, dark gray, with abundant and irregular shaly partings, some metabentonite beds present	Fill			
			ANNVILLE FORMATION (LV)	Oa	Between 135 and 180 feet, thins westward to 29 feet	Limestone very pure (high calcium content), light gray; massive bedding, weathered very light gray, may be streaked very light gray and medium dark gray	Exceptional High Calcium Limestone			
			SAINT PAUL GROUP (CV)	Osp	580 feet at west end of area, probably 1000 feet thick at Le mer [illegible]	"Birdseye" limestone light gray, thick bedded high calcium, prominent bands and zones of medium-gray granular limestone and black, chert bearing limestone, some dolomite and skeletal detrital limestone	Aggregate and Metallurgical Grade Rock			
LOWER ORDOVICIAN		BEEKMANTOWN GROUP	PINESBURG STATION FORMATION (CV)	Ops	Estimated thickness of 175-300 feet in CV area	Light colored, thick bedded, finely laminated to banded dolomite containing coarse, black chert nodules and small white quartz rosettes, with interbeds of blue gray limestone that increase in abundance westward	Fill			
			ROCKDALE RUN FORMATION (CV)	Orr	Estimated 2000-2500 feet	Light gray, medium to thick bedded limestone laminated light gray to buff colored dolomite present in the upper half of the unit, chert is present in the middle and near the top of the unit 500 feet of pure marble like limestone at the base of the unit, locally the [illegible] has a pink tint	Building Stone[4] and Aggregate			
			ONTELAUNEE FORMATION (LV)		Estimated 700 feet	Medium to dark gray massive bedded dolomite some chert at base up to 10' [illegible] of limestone, dolomite weathers yellowish gray and is intricately jointed limestone weathers light gray with conspicuous yellowish gray to grayish brown laminae	Aggregate and Metallurgical Grade Rock			
			EPLER FORMATION (LV)	Oe	1100 feet	Interbedded limestone and dolomite dolomite is medium dark gray, limestone [illegible] gray, beds up to 2 feet thick [illegible] weathers yellowish gray and is intricately jointed limestone weathers [illegible] gray with conspicuous yellowish gray to grayish brown laminae	Aggregate and Metallurgical Grade Rock[5]			
			STONEHENGE FORMATION (LV CV)	Osh	Maximum of 1500 feet in LV area 100-500 feet in LV area	[illegible] light to medium gray limestone [illegible] thick bedded dolomite [illegible] chert bearing limestone beds in V area increasing in abundance to the west	Building Stone			
			STOUFFERSTOWN FORMATION (LV)	Osf	200 feet	Coarse grained, medium to dark gray [illegible] edgewise conglomerate present, dark gray [illegible] former	Aggregate			
CAMBRIAN	[illegible]	CONOCOCHEAGUE GROUP	SHADYGROVE FORMATION (LV)	[illegible]	Not differentiated in project area	Mostly very light gray to pinkish gray [illegible] abundant nodules of [illegible] limestone [illegible] limestone in part, beds of finely detrital	Building Stone and Aggregate			
			ZULLINGER FORMATION (LV)							
			[illegible]	[illegible]	Approximately [illegible] 800 1100 feet	Sandy, light to pinkish gray [illegible] dolomite, medium to thick bedded [illegible] some interbedded [illegible] to a yellowish gray	Aggregate			

NOTES

1 [illegible] are used by the authors for the [illegible] sandstone [illegible] exposed in the northern part of the area

2 The [illegible] Member of the Gettysburg Formation used by Stose, G. W. and Jonas, A. I. (1939) is deleted in the York County portion of the project area because of the lack of [illegible] an appropriate unit

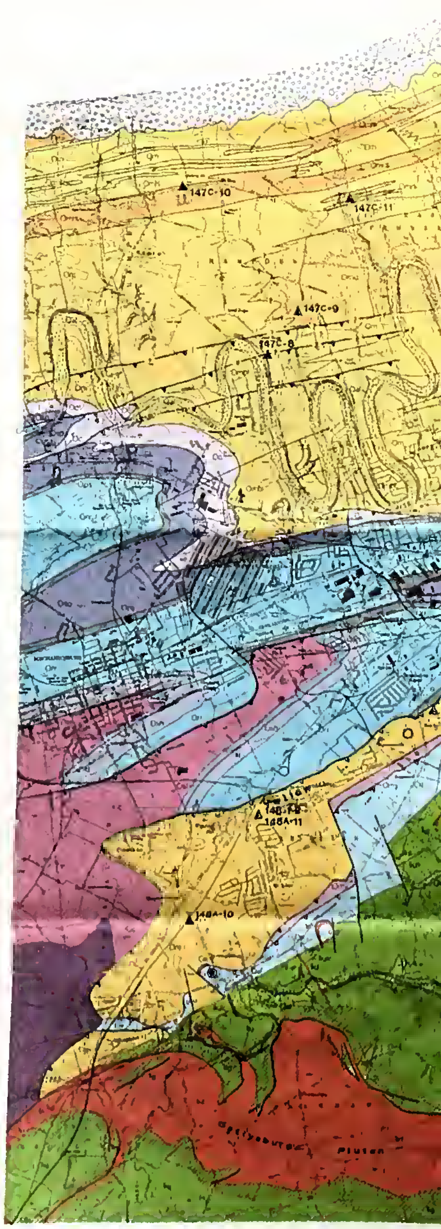
3 LV [illegible] rock names derived from [illegible] Valley sequence west of Susquehanna River [illegible] CV names derived from Lebanon Valley sequence [illegible]

4 The potential as a building stone has been [illegible] and Hood (1971)

5 The Epler Formation has been used [illegible] blast furnace operations

LEGEND FOR CROSS SECTION

- Trd DIABASE
- "BAKED" SEDIMENTS
- Trgs INTERBEDDED RED SHALE, SILTSTONE AND SANDSTONE
- INTERBEDDED GRAY SHALE SILTSTONE AND SANDSTONE
- Ohm, Oc SHALY LIMESTONE
- Oa, Osp/Ops, Orr CARBONATES (LIMESTONE AND DOLOMITE)
- MOVEMENT OF ROCKS ALONG FAULT
- FAULT
- DIP (INCLINATION OF BEDS)



Geologic data from S. I. Root (personal communication), G. W. Stose and A. I. Jonas, 1939, D. B. MacLachlan, 1967, L. D. Carswell and others, 1968 and [illegible] McLaughlin manuscript maps

COMMONWEALTH OF PENNSYLVANIA
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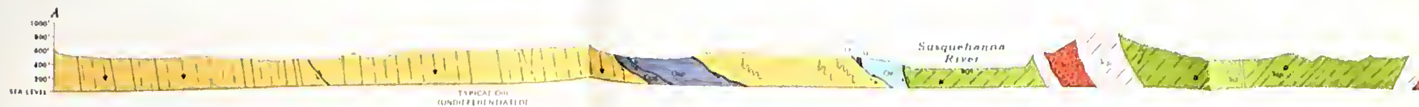


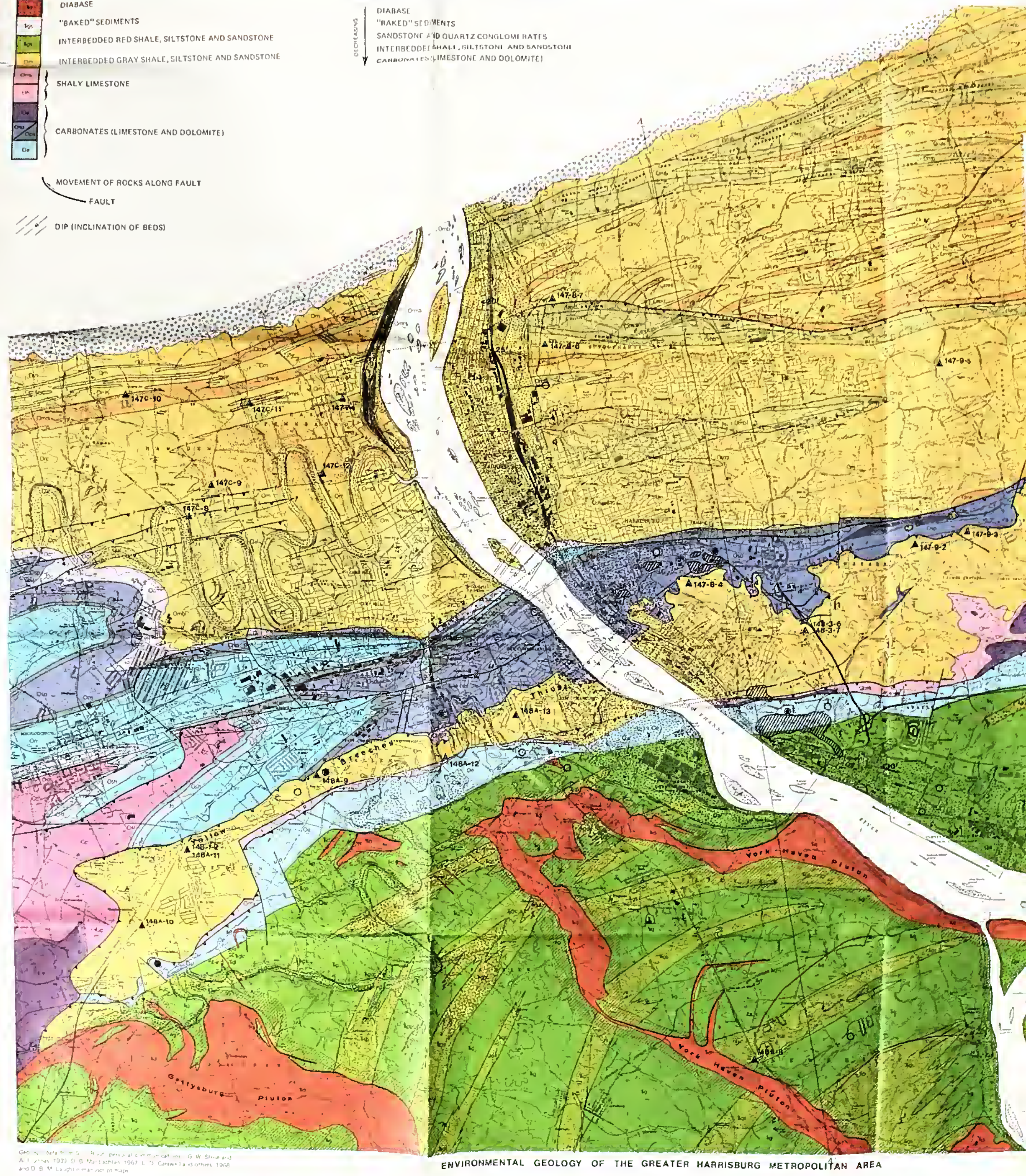
GEOLOGIC CROSS SECTIONS SHOWING ATTITUDES OF ROCK STRATA AND RELATIONSHIPS OF ROCK TYPE TO TOPOGRAPHY
VERTICAL EXAGGERATION 4X

LEGEND FOR CROSS SECTION

- 🟥 DIABASE
- ⬜ "BAKED" SEDIMENTS
- 🟩 INTERBEDDED RED SHALE, SILTSTONE AND SANDSTONE
- 🟨 INTERBEDDED GRAY SHALE, SILTSTONE AND SANDSTONE
- SHALY LIMESTONE
- CARBONATES (LIMESTONE AND DOLOMITE)
- MOVEMENT OF ROCKS ALONG FAULT
- FAULT
- DIP (INCLINATION OF BEDS)

RESISTANCE OF ROCKS IN THE METRO AREA TO WEATHERING

DECREASING ↓
DIABASE
"BAKED" SEDIMENTS
SANDSTONE AND QUARTZ CONGLOMERATES
INTERBEDDED SHALE, SILTSTONE AND SANDSTONE
CARBONATES (LIMESTONE AND DOLOMITE)

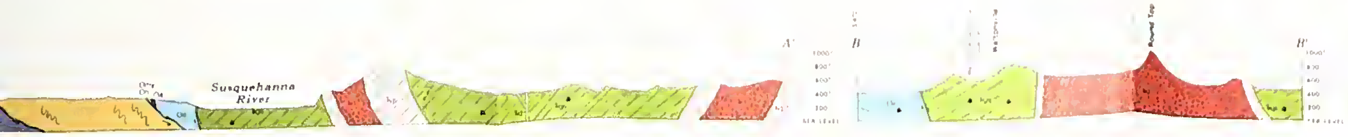


Geologic data from S. I. Root, personal communication; G. W. Stose and A. I. Jonas, 1933; D. B. MacLachlan, 1967; L. D. Carswell and others, 1968 and D. B. MacLachlan manuscript maps.

ENVIRONMENTAL GEOLOGY OF THE GREATER HARRISBURG METROPOLITAN AREA

PLATE 5

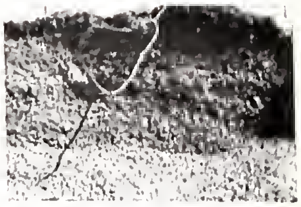
…S



GEOLOGIC CROSS SECTIONS SHOWING ATTITUDES OF ROCK STRATA
AND RELATIONSHIPS OF ROCK TYPE TO TOPOGRAPHY
VERTICAL EXAGGERATION 4X

…O WEATHERING

…RATES
… SANDSTONE
…ITE)

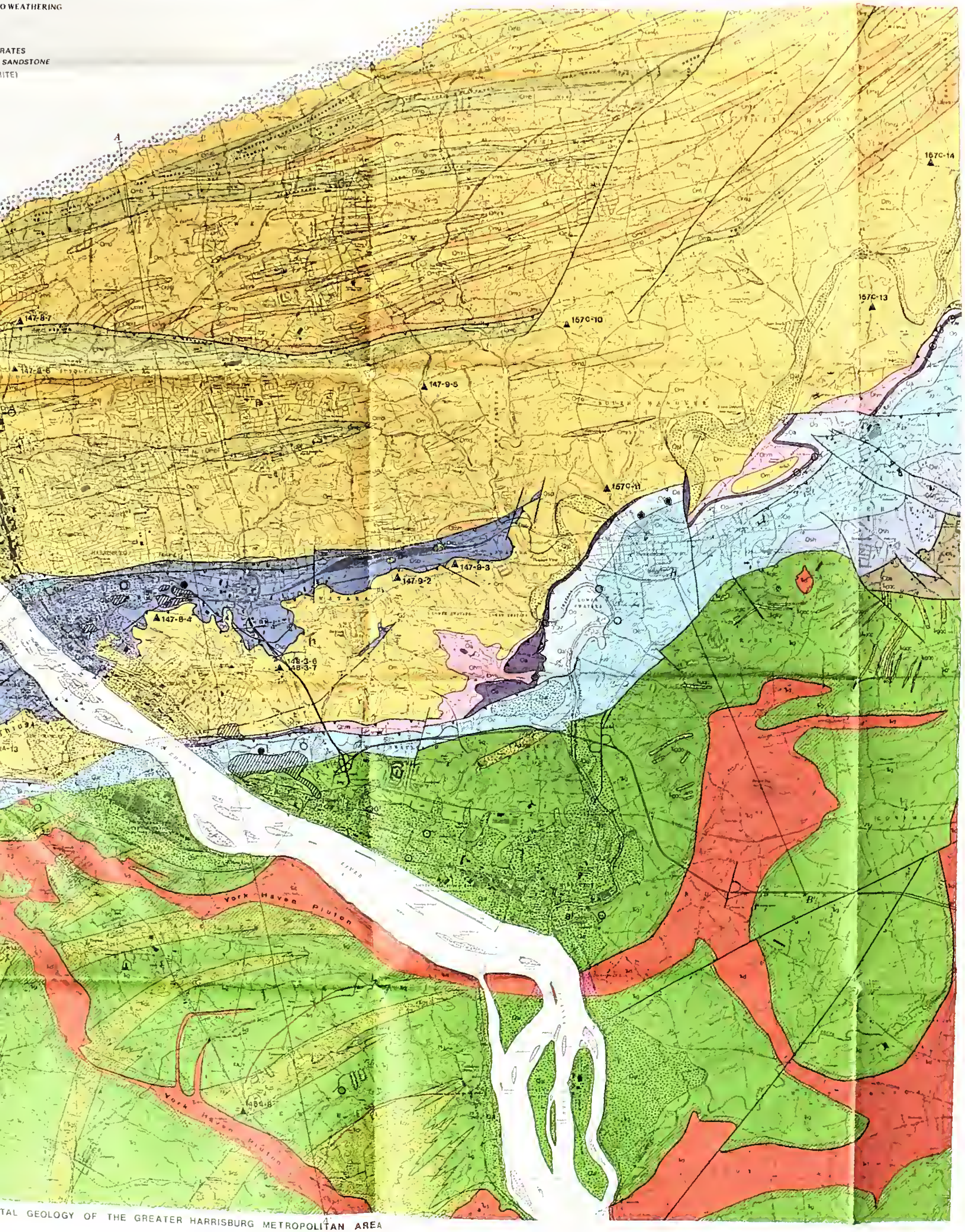


Gravel deposit in the Susquehanna River floodplain near the southeast corner of the borough of Highspire

Folded graywacke sandstone, Martinsburg Formation, in Wormleysburg Cumberland County

Rockdale Run Formation at the Township School Shiremanstown Cumberland County

Hempt Brothers quarry exposing the St Paul Group, Lower Allen Township, Cumberland County



MAP EXPLANATION

definite inferred concealed
Formation Contact

Fault (high angle, thrust)

Strike and Dip of Beds

Axis of Anticline

Horizontal Beds

Axis of Overturned Anticline

Vertical Beds

Axis of Syncline

Strike and Dip of Overturned Beds

Axis of Overturned Syncline

Strike and Dip of Cleavage

Strike and Dip of Foliation, may be bedding, cleavage or both

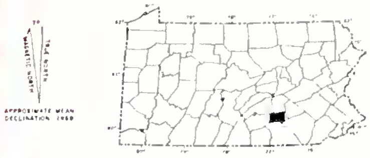
Horizontal Cleavage

▨ Slag dumps, waste piles of quarries and structural landfills

● Quarry or borrow pit active

○ Quarry or borrow pit abandoned

▲ 147-9-2 Physical test data from grab and channel samples sample data by county and sample number may be found in Mineral Resource Reports 51 and 63



GEOLOGIC
AND
MINERAL RESOURCE MAP

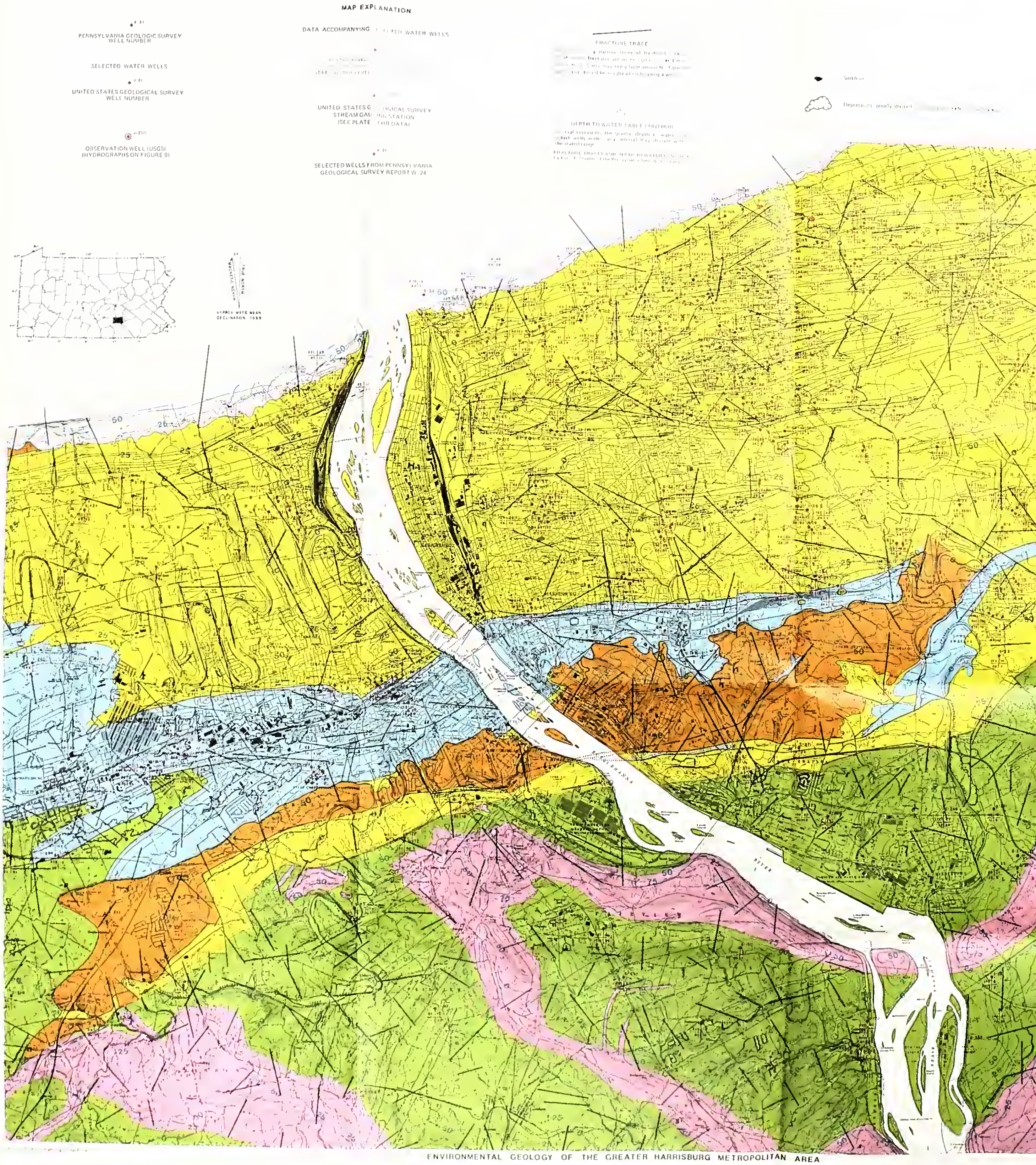
SCALE [illegible]

TAL GEOLOGY OF THE GREATER HARRISBURG METROPOLITAN AREA

Albert E. VanOlden, Cartographer

TOPOGRAPHIC AND GEOLOGIC SURVEY
Arthur A. Socolow, *State Geologist*

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES


MAP EXPLANATION
PENNSYLVANIA GEOLOGIC SURVEY WELL NUMBER
SELECTED WATER WELLS
UNITED STATES GEOLOGICAL SURVEY WELL NUMBER
OBSERVATION WELL (USGS) (HYDROGRAPHS ON FIGURE 9)
DATA ACCOMPANYING SELECTED WATER WELLS
UNITED STATES GEOLOGICAL SURVEY STREAM GAUGING STATION (SEE PLATE FOR DATA)
SELECTED WELLS FROM PENNSYLVANIA GEOLOGICAL SURVEY REPORT W 24
FRACTURE TRACE
DEPTH TO WATER TABLE CONTOUR
Sinkhole
Depression, poorly drained
TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION 1959
HARRISBURG
SUSQUEHANNA
RIVER
50
25

ENVIRONMENTAL GEOLOGY OF THE GREATER HARRISBURG METROPOLITAN AREA

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES

FG-4
PLATE 6

FRACTURE TRACE

Delineates long narrow zones of fractured rock. In these zones fractures are more numerous and more open; these zones may carry large amounts of ground water and should be sought when locating a well

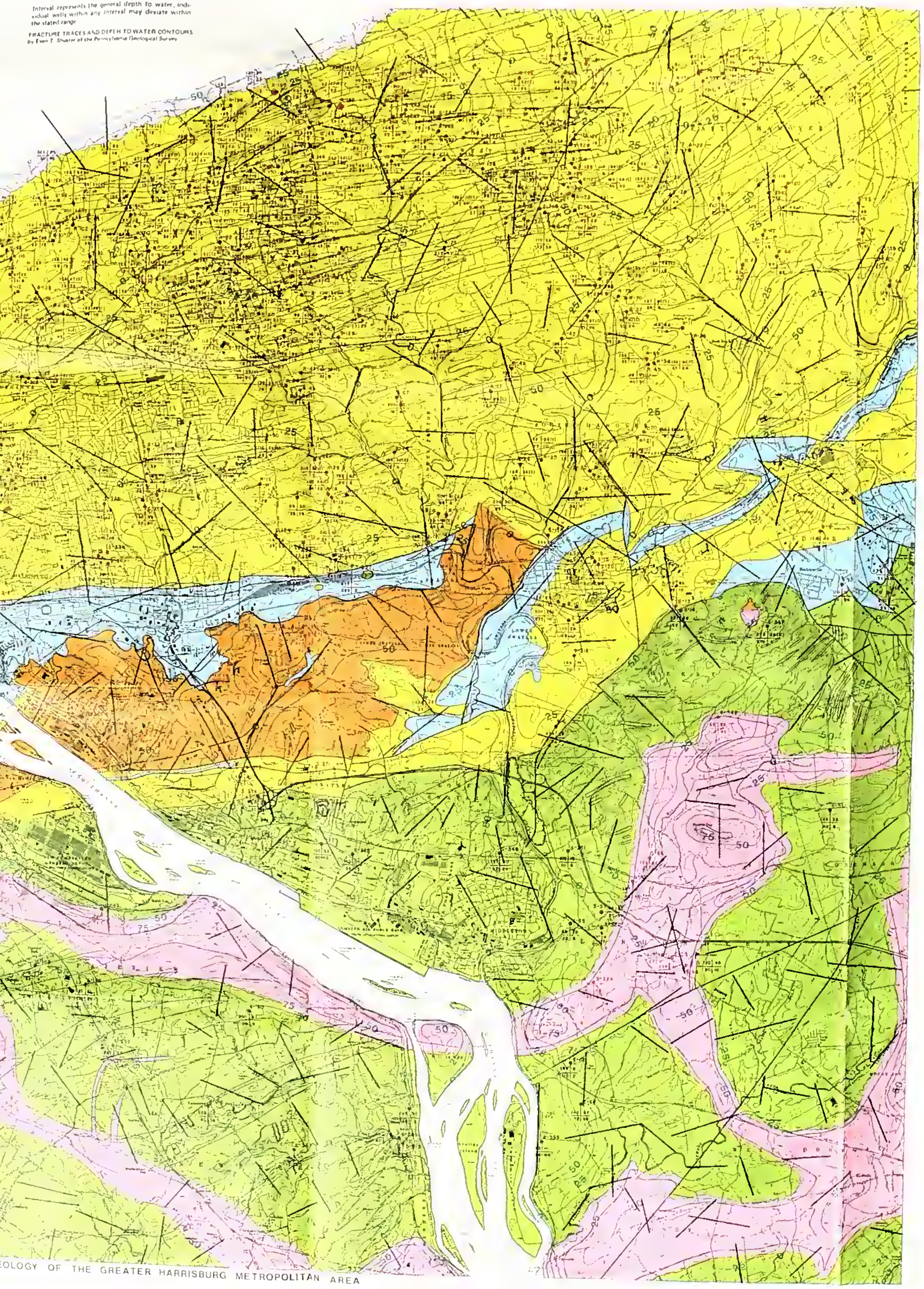
DEPTH TO WATER TABLE CONTOUR

Interval represents the general depth to water, individual wells within any interval may deviate within the stated range

FRACTURE TRACES AND DEPTH TO WATER CONTOURS by Evan T. Shuster of the Pennsylvania Geological Survey

Sinkhole

Depressions, poorly drained, may represent extensive bedrock solution



VALUE	MAP COLOR	NAME OF ROCK UNIT MAP SYMBOL	DELIVERABILITY DATA		WATER QUALITY	RECOMMENDED WELL SITES AND WELL DEPTHS	COMMENTS
			YIELD	SPECIFIC CAPACITY			
EXCELLENT	🟦	Annville Formation [illegible]	Reported range [illegible] gpm	[illegible]	[illegible]	[illegible]	[illegible]
	🟦	Ontelaunee Formation [illegible]	Reported range 1 210 gpm	[illegible] 44 gpm per [illegible] drawdown	[illegible]	[illegible]	[illegible]
	🟦	Rockdale Run Formation [illegible]	Reported range [illegible] gpm		Very hard	[illegible]	[illegible]
	🟦	Saint Paul Group [illegible]	Reported range [illegible] gpm		[illegible]	[illegible]	[illegible]
	🟦	Stonehenge Formation [illegible]	Reported range [illegible] gpm	[illegible]	[illegible]	[illegible]	
GOOD	🟩	Buffalo Springs Formation [illegible]	Reported range 12 30 gpm	[illegible] gpm per [illegible] drawdown [illegible]	[illegible]	[illegible]	
	🟩	Elbrook Formation [illegible]	Reported range 4 100 gpm				
	🟩	Conococheague Group [illegible]	Reported range 1 40 gpm	Range [illegible] 150 gpm (Median 1.0 gpm per foot of drawdown)	[illegible]	[illegible]	
	🟩	Gettysburg Formation [illegible]	Average [illegible] gpm [illegible]	Range [illegible] gpm per foot of drawdown [illegible]	[illegible]	[illegible]	
POOR	🟨	Chambersburg Formation [illegible]	Reported range 30 720 gpm		[illegible]	[illegible]	
	🟨	Epler Formation [illegible]	Reported range 1 300 gpm	(Median 0.3 gpm per foot of drawdown [illegible])	[illegible]	[illegible]	[illegible]
	🟨	Hershey Formation and Hershey Myerstown Formation (Undifferentiated) [illegible]	Reported range 18 25 gpm	(Median 0.4 gpm per foot of drawdown)	Very hard. Median [illegible]	[illegible]	[illegible]
	🟨 🟧	Martinsburg Formation Om	limestone 60 300 gpm sandstone 10 50 gpm shale 10 50 gpm	(Median 1.0 gpm per foot of drawdown)	Hard. Very [illegible]	[illegible]	[illegible]
VERY POOR	🟪	Baked Zones and Diabase [illegible]	< 10 gpm		Moderately hard. May have high iron content	[illegible]	[illegible]

GENERAL COMMENTS

1. The general availability of ground water was determined from well records and pump tests collected and produced by the Pennsylvania Geological Survey and the U.S. Geological Survey, in areas of few and no wells potential well yields are inferred from geologic data. Special investigations are needed to determine specific factors such as sustained yields of aquifers and suitability of water for use in any given site or area.
2. The well data presented on the map are primarily from domestic wells, this information may not conform to the specific capacity data given in the chart in that the latter data represent median figures for a formation over a wide area.
3. Depth to water below the land surface [illegible] on data collected during different [illegible] several different years. Water levels [illegible] seasonally, generally closest to the land surface during early spring and deepest in late summer; the amount of fluctuation depends [illegible] topography, type of bedrock, and [illegible] distribution of precipitation.
4. The Stouffferstown, Pinesburg Station and Myerstown formations are very limited in areal extent, no meaningful ground water information is available.
5. The map may be used to determine a possible conflict between an important aquifer and the use of the site; a site may need special preparation to protect the aquifer from possible contamination or a decision made to avoid the use of the land.

GROUND WATER AVAILABILITY MAP

SCALE [illegible]

EOLOGY OF THE GREATER HARRISBURG METROPOLITAN AREA